

DATE: October 11, 2018

SUBJECT: Madison Metropolitan Sewerage District (Madison Met) Chloride Variance Application

The Department has determined that a water quality-based effluent limitation (WQBEL) for chloride is needed in this permit to protect aquatic life. As allowed under s. NR 283.15(2), Wis. Stats, the permittee has requested a variance to the chloride water quality criterion. In support of this request, the permittee has submitted documentation to demonstrate that human caused conditions would cause more environmental damage to correct than to leave in place consistent with s. NR 283.15(4)(a)1.c., Wis. Stats and 40 CFR 131.10(g)(3). The specific supporting documentation may be found in Attachments A-F below. The Department concurs with Madison's demonstration; however, this concurrence is subject to US EPA approval before the variance may be included in the final reissued permit.

The Department is soliciting comments regarding the above-mentioned variance during this public notice period and will hold a public informational hearing on December 7, 2018. As part of this public notice package the following attachments were submitted and are being made available to assist with the public's review of the proposed variance:

- A. **Madison Metropolitan Sewerage District's Public Notice**, prepared by Madison Met
- A.2. **Additional Narrative Justification**, prepared by Madison Met
- B. **Facility Specific Chloride Variance Data Sheet**, prepared by WDNR
- C. **Pollutant Minimization Plan (PMP)**, prepared by Madison Met
- C.2. **PMP Addendum**, prepared by Madison Met
- D. **Simplified Triple Bottom Line**, prepared by Madison Met
- E. **Chloride Compliance Study Report (Excerpts Only)** – *the entire study is available at www.madsewer.org by searching "chloride compliance study".*, prepared by Madison Met
- F. **Small Business Case Study**, prepared by Madison Met

Additional documents related to permit reissuance including but not limited to variance annual reports, application, and supporting documents are available upon request.



**Attachment A – Madison Metropolitan Sewerage District's
Public Notice**

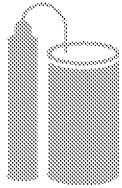
Reducing chloride at its source:

A better path to clean water

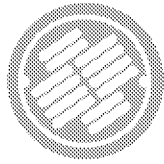
Since 2010, Madison Metropolitan Sewerage District has been working to reduce chloride (a component of salt) throughout the Madison area with a goal of meeting water quality standards and protecting fresh water. Every five years, the district must apply for a new operating permit with the Wisconsin Department of Natural Resources. In its upcoming permit, the district is pursuing renewal of their chloride variance to achieve the best possible outcomes for the environment and communities we serve.

Sources and paths of chloride

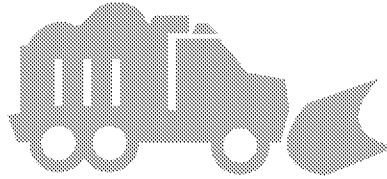
More than 100 tons of salt reach Madison Metropolitan Sewerage District's wastewater treatment plant each day, and additional thousands of tons of salt are applied to roads, sidewalks and parking lots in the winter. Chloride levels above state standards pollute fresh water and threaten wildlife.



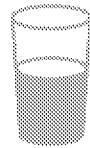
Water softeners in homes and businesses send all the salt they use to the sewer. In this area, water softeners are the main sources of salt in wastewater.



Salt in the sewer ends up at the wastewater treatment plant. The plant isn't able to remove chloride, so it is discharged into local freshwater streams.



Road salt can end up at the wastewater treatment plant, too, though most runs directly into lakes, rivers and streams.

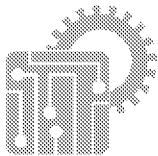


Some road salt also filters down into underground drinking water wells, elevating levels of chloride in our drinking water.

Options for reducing chloride

The district's Nine Springs Wastewater Treatment Plant, like most wastewater plants, is not designed to remove dissolved chloride. The district's permit contains a requirement to meet state chloride limits but at times, water reaching the plant exceeds these limits. In 2015, the district commissioned an engineering study to evaluate technological options at the plant to comply with these limits. At the same time, the district's chloride reduction efforts in partnership with local businesses and government were already generating positive results. The study showed that implementing expensive treatment technology would only reduce chloride downstream of the Nine Springs Wastewater Treatment Plant while incurring significant environmental costs. The study is available at www.madsewer.org by searching "chloride compliance study."

Treatment technologies



To reach water quality standards, one treatment option involves installation of reverse osmosis or other technologies at the treatment plant to remove incoming chloride from a portion of the wastewater received each day. This option carries heavy environmental and ratepayer costs due to energy use and the need for concentrated brine disposal. The installation of water softening technology at some area drinking water wells also could reduce overall salt use. In addition to installation costs, this option would depend on the removal of softeners from homes and business and coordination among more than 15 drinking water utilities, the participation of which is beyond control of the district.

Source reduction with variance



Source reduction of chloride involves working with individuals and businesses to reduce salt use, decreasing the amount of salt that ends up at the treatment plant and in local water bodies. This alternative, which includes water softener efficiency programs and road salt reduction, is a path to permit compliance while also improving water quality in all our lakes, rivers and streams. A variance allows time for the district to form partnerships, support development of training and certification programs, create and award grants and rebates as well as conduct outreach and education to reduce salt use.

Engineering study findings on chloride compliance options

The 2015 engineering study identified a variety of compliance options and compared them by evaluating their financial, social and environmental impacts, known as a triple bottom line analysis. The table below demonstrates how use of the most sustainable technical treatment option compares to source reduction. The technical option would treat a small percentage of the daily flow and would not produce significant reductions of phosphorus or other pollutants.

	Treatment using reverse osmosis and brine minimization through evaporation and crystallization	Source reduction (softening and industrial improvements, road salt optimization, outreach and education)
Amount of wastewater treated	7.3 million gallons per day average (<20% of average influent)	None
Wisconsin water quality criterion: 395 milligrams per liter weekly average	Meets standard	Meets standard
Energy increase	80,000 megawatt-hours per year	No expected change
Carbon footprint increase	46,500 metric tons carbon dioxide equivalents per year	No expected change
Cost	\$464 million	\$1 million
Timeline	3 years	10 years or more
Other benefits	Chloride reduction in water downstream of plant	Chloride reduction in lakes, rivers and drinking water upstream and downstream of the plant

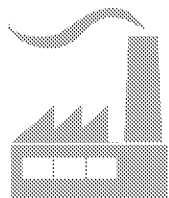
A variance with source reduction represents the best path forward. Here's why:



Chloride source reduction would benefit overall water quality more than end-of-pipe treatment

The district discharges clean water south of Madison, so all the chloride in the Yahara chain of lakes and in drinking water wells is from road salt. By reducing all sources of chloride, instead of just the portion that reaches the treatment plant, the district can continue to extend protection to more lakes, rivers and streams.

10,000
Number of households that could be powered by the energy necessary to treat for chloride



End-of-pipe treatment is hard on the environment

Technological solutions would emit thousands of tons of greenhouse gases each year, significantly increasing the plant's carbon footprint. Additionally, treatment would create a concentrated brine waste that would need to be trucked long distances and disposed of in the environment.

5
Gallons of fresh water protected by reducing one teaspoon of salt

As a result of these findings and the success of source reduction efforts to date, Madison Metropolitan Sewerage District has made a preliminary determination that a variance with source reduction is the best option to protect all local waters from chloride pollution. This option allows the district time to continue working with industrial users, water softening companies, road salt applicators and others to reduce all sources of salt and protect local fresh waters.

To learn more visit www.madsewer.org and search "chloride reduction."

Attachment A.2 – Additional Narrative Justification

Chloride Variance Supporting Documentation

When the State of Wisconsin implemented water quality standards for chloride, they also developed the foundation for the chloride variance found in Wis. Admin Code NR 106.83(2). The State findings for variance in Administrative Code were approved by the US Environmental Protection Agency, codified into state law, and include the department findings that:

1. End-of-pipe wastewater treatment technology for chloride is prohibitively expensive;
2. End-of-pipe wastewater treatment technology for chloride produces a concentrated brine that can be as much or more of an environmental liability than the untreated effluent;
3. Appropriate chloride source reduction activities are preferable environmentally to end-of-pipe effluent treatment in most cases; and
4. For some dischargers, attaining the applicable water quality standards specified in chs. NR 102 to 105 may cause substantial and widespread adverse social and economic impacts in the area where the discharger is located.

These findings are supported by the Madison Metropolitan Sewerage District's work during the first chloride variances and are further addressed below:

Treatment for chloride removal is prohibitively expensive.

During the first chloride variance term, Madison Metropolitan Sewerage District (District) undertook a feasibility study ([Chloride Compliance Study Nine Springs Wastewater Treatment Plant](#), referred to as Study) to determine if there were viable technological solutions to achieve compliance with the water quality standard. This is a general feasibility stage document not a facilities planning document.

While the resulting report illustrates that while there are options that could achieve compliance, it also illustrates that they are both prohibitively expensive and introduce complex environmental and social challenges which will not lead to a net environmental benefit. Specifically, there are two major possible approaches: source reduction through softening of source water or treating a portion of the effluent at the Nine Springs Wastewater Plant. The feasibility level cost projections for the options for design year range from nearly \$290 million to over \$2.3 billion (Study: Table 7-3, 20-year present worth) with a margin of error from -30% to +50%. The lower end of that range involve either softening a portion of the source water, which is outside the jurisdiction of the District or significant energy demands that may not be available in the region.

The Madison Metropolitan Sewerage District does not own, operate or in any way control the water supply system that is tributary to our plant. We are a separate government entity, developed by state statute and governed by a nine person commission. In addition to the economic, environmental and social challenges related to these approaches, significant political challenges would be involved with both developing and financing a water supply system solution. Implementing a source softening project in a developed region is extremely challenging. Since not all the source water would need to be softened to achieve compliance with the water quality standard, the study only examines treating the required portion of the source water. This leads to a variety of challenges including the need to require softeners be removed once softening is achieved (other communities have found this challenging), the creation of a disparity between residents that will need water softeners and those that do not, and making soft water the only option for some residents even in undesired situations, such as drinking water and irrigation.

The other lower cost treatment alternatives (Study: 2B, 2C, 3B, 3C) include brine minimization. These require significant additional energy that may not be available in this region (energy purchase for MMSD was 67,000 kWh/day in 2016; from the Study's Appendix E, Condensation is projected to add 50,763,000 kWh/yr or 139,000 kWh/day AND Crystallization is projected to add 58,443,000 kWh/yr or 160,000 kWh/day). 300,000 kWh/day is a significant load. For typical large customers, energy use grows over time, this project would require an immediate load increase. The average daily household use in America is estimated to be 30 kWh/day. For the energy supplier, the scale of the increase would equivalent to adding a new community with over 10,000 households. Only one of our regional communities (the City of Madison) has more households than this. Our local energy supplier notes that any new loads to the system will require a full system analysis to determine what would be needed for distribution and service to be capable of delivering the load as well as if the increased demand is achievable. With the current energy demand, the District is already one of the top energy customers for the utility and this treatment would require approximately a five-fold increase.

To further assess all options (source treatment, treatment at the plant, brine minimization), the study evaluated triple bottom line costs for eight options. There was no option that ranked high in all categories which led to significant discussion on how to weight various factors. The resulting triple-bottom-line analysis is included in Study: Appendix E.

End-of-pipe wastewater treatment technology for chloride produces a concentrated brine that can be as much or more of an environmental liability than the untreated effluent;

The District's chloride compliance study determined that treatment at the wastewater plant would involve a portion of the effluent. Initially, this portion of the effluent is estimated at 7.3 MGD and would expand to 15 MGD over the design life of the plant. This super-treated effluent would mix with the remaining effluent before discharge such that the resulting effluent would meet the water quality standard. Treating this small amount of plant effluent (~18%) creates a wasteload of concentrated brine estimated to be 1.5 million gallons/day. The study estimated disposing of this waste to require 150 trips per day (Study: Table 6-9) estimated to be 500-miles per trip. To eliminate these transportation and disposal costs, additional treatment would need to be constructed to concentrate and solidify the waste. These options require significant capital cost investment and the resulting processes are estimated to include five-fold increase in the entire District energy use. Moving forward with these options may involve capital changes to the local power supply system. These costs would also be borne by rate payers and are not accounted for in the study.

Appropriate chloride source reduction activities are preferable environmentally to end-of-pipe effluent treatment

The District's chloride source reduction program is working. Despite competing factors like new development (i.e., new water softener contributions) and winter road salt contributions, the District's average annual chloride loads have stabilized and appear to be decreasing since the commencement of the PMP in 2010 (Figure 1), suggesting that initial source reduction activities have been successful. Since 2010, there have been reductions in chloride mass, based on known reductions in chloride to the sewer system (e.g., those reported for grant-funded projects) and on chloride levels observed at the plant. The

variability and peaks in chloride concentrations are decreasing. The District's chloride program is a model for other agencies and regions. Individuals, agencies and other governments are undertaking significant chloride reduction projects and ancillary, beneficial chloride reduction activities.

The goals of the program include reducing each source of chloride including industrial contributions, water softening contributions and road salt contributions. In the course of this program, the District has invested thousands of dollars in projects to reduce chloride to the sewer system. Funded projects have ranged from conventional softener upgrades to the installation of new technologies to reduce or eliminate the use of salt. Meanwhile, other facilities have taken action to reduce independent of District funding, recognizing the inherent benefits of reducing salt use. On the road salt side, public and private applicators have altered their practices based on training programs and District funding, resulting in a decrease in chloride being applied to pavement in the area.

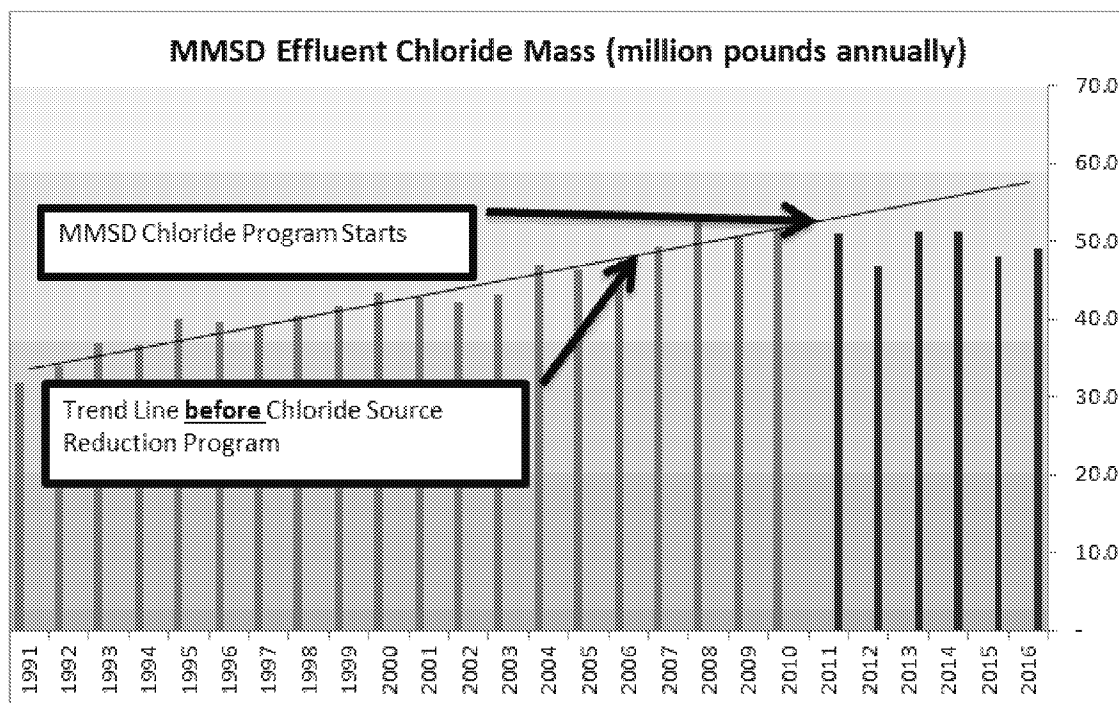


Figure 1 - MMSD Chloride Mass

The highest achievable condition of local waters will not be achieved by treating a small amount of the wastewater effluent to meet water quality standards while the long-ranging behavior change; social engagement and dedication by individuals, businesses, and communities is improving local water.

During the first term of the chloride variance, the Madison Metropolitan Sewerage District has made significant progress in reducing chloride not only directly tributary to the wastewater plant but throughout the region, state and country. Across the region, chloride is accumulating in local freshwater. Madison Dane County Public Health has identified adverse trends in local drinking water, wastewater, rivers, lakes, streams and wetlands.

While chloride accumulation is endangering freshwater organisms and impairing the aesthetic properties of drinking water, the only entity required to be working to reduce these threats is the WPDES permitted Madison Metropolitan Sewerage District. Successfully changing the social norms and behavior that results in chloride reduction to the wastewater plant has expanded the reach of the District's pollutant minimization plan past the boundaries of the wastewater treatment plant to all local water. Specific resulting successes include industries investing hundreds of thousands of dollars to redesign processes to eliminate the need for salt waste; local and national organizations investing in programs to share the need to reduce salt use with their constituents (realtors, builders, water quality professionals) the City of Madison beginning the State's first Winter Maintenance Professional Certification Program; Dane County working with local professionals to develop statewide standards for Winter Maintenance. Without the source reduction program, this momentum is likely to cease.

Changing behavior and interrupting long-held social norms, which reduce the overall chloride load to the wastewater treatment plant, are the only approaches that lead to a net environmental benefit; yet, these approaches take time to be realized. During the District's first chloride variance, the trend in chloride mass reversed (Figure 1); the social norms relating to salt have been interrupted and demand for District programs continues to increase. This foundation provides momentum continued progress and success from the source reduction program.

End of pipe wastewater treatment for chloride will cause widespread adverse social and economic impacts to the local area.

The costs of chloride treatment are prohibitively expensive and come with complex environmental and social costs that discount the validity of their adoption. The District serves over twenty diverse communities in the Greater Madison area. The range in median household income spans \$32,400/year to over \$100,000/year. Throughout each of these communities significant economic diversity exists. In Dane County, over 58% of the households are at or below the MHI; however, all residents pay sewer rates for their wastewater collection and treatment systems that are not proportional to their income level. Resilient solutions to complex challenges face a multitude of tests including providing the highest attainable use as well as a level of fairness to rate payers. Treating to remove chloride does not achieve either. Continuing the source reduction program will lead to the highest attainable use of local waters and is a more responsible use of local rate payers' resources.

In addition to facing chloride treatment costs, the District and local communities that are District customers are facing phosphorus compliance costs for both permitted wastewater discharges as well as for their stormwater compliance with the Rock River TMDL. The District is moving forward an Adaptive Management project as the compliance approach for the Badfish Creek discharge. This project is estimated to cost local rate payers nearly \$29-million dollars. In addition, the District is facing phosphorus compliance requirements for its Badger Mill Creek effluent discharge. The projected costs of this project will also range into the millions, which will also be passed along to rate payers. The District recently finalized its Liquid Process Facility Plan which will be moving into design and will involve \$53-

million of additional infrastructure investment. Any projects that were built in the next 5-years would be financed over 20-years. Over that time, it is very likely that the District will face water quality standards for nitrogen. Preliminary estimates based on the 2012 CH2M report indicate those costs would be over \$80 to 140-million, based on 2012 dollars. The District alone has over \$20 million in added costs each year to address its Capital Improvements Plan and with a treatment plant that was constructed in 1929; over 140-miles of sewers and 18-major pumping station, future infrastructure repair and replacement costs are expected to increase significantly. Rate payers in our District cover all these costs. They are distributed evenly; however, rates are not adjusted to reflect economic disparities so the cost increase will be proportionately more significant to some rate payers.

As we look to achieve compliance, options are evaluated on their ability to attain the highest attainable condition, provide a net environmental benefit and represent the overall best use of District resources. Therefore, as we evaluated chloride, we also looked at ancillary benefits and found that treating for chloride would not help the District achieve compliance with any of these other parameters. The study evaluated the result of the chloride treatment on phosphorus and nitrogen. Since only a small amount of the effluent is treated, only a small amount of the phosphorus/nitrogen is removed during reverse osmosis or electrodialysis reversal. These reductions result in effluent improvements of approximately 0.02 mg/l of treatment for phosphorus and up to 1.2 mg/l for nitrogen – which will not significantly impact treatment options or future costs (Study: Table 6-7, 6-8). In addition, chloride treatment adds significant infrastructure and assets to maintain in addition to greatly increasing our carbon footprint and energy use (Study: Appendix E).

The variance should continue.

In addition to the financial and environmental impacts, the Chloride Compliance study evaluated a variety of social impacts of treating to remove chloride. These included the impact on the District's leadership, community image and public acceptance. The Madison Metropolitan Sewerage District is committed to our Mission of Protecting Public Health and the environment. We accept responsibility for being the only regional water organization in our area. Our continued success requires a long-term vision because our work takes time to put into place and we must translate that into actions we can take today. The actions we take today impact our rate payers for years to come. The triple bottom line assessment of chloride compliance options indicates that these options do not achieve this mission or live up to this responsibility. Continuing to operate under a chloride variance allows the district to continue to implement the PMP and source reduction efforts which are showing success and take time to fully be realized.

Attachment B – Facility Specific Chloride Variance Data Sheet

Facility Specific Chloride Variance Data Sheet

Directions: Please complete this form electronically. Record information in the space provided. Select checkboxes by double clicking on them. Do not delete or alter any fields. For citations, include page number and section if applicable. Please ensure that all data requested are included and as complete as possible. Attach additional sheets if needed.

Section I: General Information

A. Name of Permittee: MADISON METROPOLITAN SEWERAGE DISTRICT
B. Facility Name: MADISON METROPOLITAN SEWERAGE DISTRICT WWTF
C. Submitted by: Wisconsin Department of Natural Resources
D. State: Wisconsin **Substance:** Chloride **Date completed:** October 11, 2018
E. Permit #: WI-0024597-09-0 **WQSTS #:** (EPA USE ONLY)
F. Duration of Variance **Start Date:** April 1, 2019 **End Date:** March 31, 2024
G. Date of Variance Application: February 26, 2015
H. Is this permit a: ☐ First time submittal for variance
☒ Renewal of a previous submittal for variance (Complete Section IX)

I. Description of proposed variance: Variance for chloride from the water quality based effluent limits of 395 mg/L, expressed as a weekly average limit, to an interim limit of 465 mg/L (November – March) and 430 mg/L (April – October). The permit will include a requirement to implement source reduction measures and a chloride target value of 419 mg/L.

J. List of all who assisted in the compilation of data for this form

Name	Email	Phone	Contribution
Phillip Spranger	phillip.spranger@wisconsin.gov	608-273-5969	Permit Drafter
Amy Garbe	amy.garbe@wisconsin.gov	262-574-2135	Compliance Engineer
Rachel Fritz	rachel.fritz@wisconsin.gov	608-267-7657	Parts II D-H and J
Jim Schmidt	Retired	-	Environmental Analysis portions of datasheet
Laura Dietrich	Laura.dietrich@wisconsin.gov	262-574-2159	Variance Coordinator

Section II: Criteria and Variance Information

A. Water Quality Standard from which variance is sought: Chloride (395 mg/L chronic toxicity criterion)

B. List other criteria likely to be affected by variance: None

C. Source of Substance: Primarily from commercial and residential water softener regeneration brine, road salt intrusion into the sewage collection system, car washes and certain industrial contributors.

D. Ambient Substance Concentration: 0 mg/L ☒ Measured ☐ Estimated
☒ Default ☐ Unknown

E. If measured or estimated, what was the basis? Include citation. Background streamflow in Badfish Creek is zero, so the background chloride concentration is irrelevant. Badger Mill creek does have a non-zero background flow, but it is so much less than the Outfall 005 discharge rate that background chloride is irrelevant there too. To assess downstream impacts, though, State Lab of Hygiene information (through 2015) indicates ambient levels of 22 mg/L in the Sugar River at Valley Road, 57 mg/L in the Yahara River in Madison, and 38 mg/L in the Rock River at Indianford.

F. Average effluent discharge rate: **Maximum effluent discharge rate:** Design Flows
 Outfall 001: 37 MGD Outfall 001: 65 MGD
 Outfall 005: 3.4 MGD Outfall 005: 3.6 MGD

G. Effluent Substance Concentration: 1-day P₉₉= 489 mg/L (annual) ☒ Measured ☐ Estimated
 4-day P₉₉= 446 mg/L (annual) ☐ Default ☐ Unknown
 Mean = 408 mg/L (annual)

H. If measured or estimated, what was the basis? Include Citation.

1-day and 4-day P₉₉ values were calculated from 1,979 sample results taken from 01/01/2011 to 06/30/2016

ED 004376 00117742-00013

F. Provide the equation used to calculate that distance (Include definitions of all variables, identify the values used for the clarification, and include citation):

Some dilution is provided by the Yahara River (7Q10 = 21 cfs at Stoughton), but a mass balance of a discharge at a design flow of 65 MGD at Outfall 001 with $\frac{1}{4}$ of the 7Q10 will reduce instream chloride levels by only a small amount. Estimated reduction based on a mass balance is only about 22 mg/L for the interim cold-weather limit of 465 mg/L. It is therefore assumed that during dry-weather conditions the criterion will not be achievable in the Yahara River. In the Rock River (another 7 miles further downstream of the mouth of Badfish Creek), the 7Q10 is 140 cfs, so mixing with $\frac{1}{4}$ of that flow (plus the Yahara River flow) would result in chloride concentrations falling below the 395 mg/L criterion. The mass balance concentration after mixing in the Rock River is estimated at around 310 mg/L. It is therefore assumed that compliance with the chloride criterion as a result of the variance will occur after the discharge reaches the Rock River, some 27 miles from the outfall.

G. What are the designated uses associated with the direct receiving waterbody, and the designated uses for any downstream waterbodies until the water quality standard is met?

Badfish Creek is Limited Aquatic Life at point of discharge, changing to Limited Forage Fish Approx. 5 mi. downstream after confluence with Oregon Branch. Yahara River and Rock River are classified as warmwater sport fish communities. The designated uses are not significant in terms of chloride since the chronic toxicity criterion for chloride is 395 mg/L in all Wisconsin surface waters.

H. Identify all other variance permittees for the same substance which discharge to the same stream, river, or waterbody in a location where the effects of the combined variances would have an additive effect on the waterbody: None

Permit Number	Facility Name	Facility Location	Variance Limit [mg/L]
N/A	N/A	N/A	N/A

I. Please attach a map, photographs, or a simple schematic showing the location of the discharge point as well as all variances for the substance currently draining to this waterbody on a separate sheet

J. Is the receiving waterbody on the CWA 303(d) list? If yes, please list the impairments below. ☒ Yes ☐ No ☐ Unknown

Badfish Creek River Mile	Pollutant	Impairment
0-20 miles	PCB	Contaminated Fish Tissue
0-12.3 miles	Total Phosphorus	Water Quality Use Restrictions

Section III B: Location Information – Badger Mill Creek (Outfall 005)

A. Counties in which water quality is potentially impacted: Dane and Green

B. Receiving waterbody at discharge point: Badger Mill Creek

C. Flows into which stream/river? Sugar River **How many miles downstream?** 4.65

D. Coordinates of discharge point (UTM or Lat/Long): Lat: 42.99414° N / Lon: 89.50400° W

E. What is the distance from the point of discharge to the point downstream where the concentration of the substance falls to less than or equal to the chronic criterion of the substance for aquatic life protection?
4.65 miles

F. Provide the equation used to calculate that distance (Include definitions of all variables, identify the values used for the clarification, and include citation):

The Sugar River 7Q10 is 7.8 cfs above the mouth of Badger Mill Creek. A discharge of 465 mg/L chloride (variance limit during cold-weather months) at Outfall 005 at the design flow of 3.6 MGD, mixed with $\frac{1}{4}$ of the 7Q10 at 22 mg/L would result in a downstream mix concentration of 350 mg/L, which is below the 395 mg/L chronic toxicity criterion for chloride. It is therefore assumed the criterion will be met after the discharge mixes with the Sugar River flow.

G. What are the designated uses associated with the direct receiving waterbody, and the designated uses for

any downstream waterbodies until the water quality standard is met?

Limited Forage Fish at point of discharge, changing to coldwater community in the Sugar River approximately four miles downstream at STH 69.

H. Identify all other variance permittees for the same substance which discharge to the same stream, river, or waterbody in a location where the effects of the combined variances would have an additive effect on the waterbody: None

Permit Number	Facility Name	Facility Location	Variance Limit [mg/L]
N/A	N/A	N/A	N/A

I. Please attach a map, photographs, or a simple schematic showing the location of the discharge point as well as all variances for the substance currently draining to this waterbody on a separate sheet

J. Is the receiving waterbody on the CWA 303(d) list? If yes, please list the impairments below. None ☐ Yes ☒ No ☐ Unknown

River Mile	Pollutant	Impairment
N/A	N/A	N/A

K. Please list any contributors to the POTW in the following categories:
May need to contact facility for this information

Food processors (cheese, vegetables, meat, pickles, soy sauce, etc.)	None since Kraft-Oscar Mayer ceased operation in early 2017.
Metal Plating/Metal Finishing	Eight metal finishing businesses. None of these industries is known as a significant contributor of chloride.
Car Washes	See Attachment to chloride variance application for a map of car wash locations.
Municipal Maintenance Sheds (salt storage, truck washing, etc.)	Information on salt storage areas is provided in Attachment 2 to the chloride variance application.
Laundromats	Industrial Laundries: Aramark, Cintas US Energy Services, Madison United Healthcare, Superior Health Linens, WM. S. Middleton VA hospital. Multiple small cleaner/laundries.
Other presumed commercial or industrial chloride contributors to the POTW	Sanimax, Danisco, area hospitals. Others may be identified as part of on-going pollution prevention/source reduction initiatives

L. If the POTW does not have a DNR-approved pretreatment program, is a sewer use ordinance enacted to address the chloride contributions from the industrial and commercial users? If so, please describe.
Madison Met. has a DNR approved pretreatment program.

Section IV: Pretreatment (complete this section only for POTWs with DNR-Approved Pretreatment Programs. See w:\Variances\Templates and Guidance\Pretreatment Programs.docx)

A. Are there any industrial users contributing chloride to the POTW? If so, please list.

Scientific Protein Labs (SPL) is a large contributor with whom MMSD has undertaken a monitoring/reporting program. Hydrite Chemical and Pfizer have both applied for MMSD rebates to improve the efficiency of their systems (reduce chloride to sewer) and Madison Kipp Corporation is evaluating their opportunities for chloride reduction. Madison Met has identified industrial input as 18% of the influent chloride loading.

The large industry (Kraft) that had an industrial chloride permit shut down and ceased operation.

B. Are all industrial users in compliance with local pretreatment limits for chloride? If not, please include a

<p>list of industrial users that are not complying with local limits and include any relevant correspondence between the POTW and the industry (NOVs, industrial SRM updates and timeframe, etc) Madison Met does not have pretreatment limits for chlorides.</p>
<p>C. When were local pretreatment limits for chloride last calculated? Madison Met does not have a local pretreatment limit for chlorides in its sewer use ordinance and, as far as the Department knows, has never calculated such a limit.</p>
<p>D. Please provide information on specific SRM activities that will be implemented during the permit term to reduce the industry's discharge of the variance pollutant to the POTW More than half of the influent chloride is due to home softeners, and so not many SRM activities are directed to industries. The SRM plan dated May 2017 lists the following SRM activities that focus on industries:</p> <ol style="list-style-type: none"> 1. Implement Sewer Use Ordinance Revisions that allow MMSD to issue BMP oriented general permits to industries 2. Industrial pretreatment inspections 3. Analyze user charge program samples for chloride and evaluate the viability of adding chloride as a billing parameter. <p>Madison Met also continues to implement their grant and rebate program which targets commercial, industrial and multi-unit residential facilities to implement projects that reduce salt in their facilities. For additional information please visit http://www.madsewer.org/Programs-Initiatives/Chloride-Reduction/Chloride-Grants.</p>
<p>Section V: Public Notice</p> <p>A. Has a public notice been given for this proposed variance? <input type="checkbox"/> Yes <input type="checkbox"/> No</p> <p>B. If yes, was a public hearing held as well? <input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> N/A</p> <p>C. What type of notice was given? <input type="checkbox"/> Notice of variance included in notice for permit <input type="checkbox"/> Separate notice of variance</p> <p>D. Date of public notice: _____ Date of hearing: _____</p> <p>E. Were comments received from the public in regards to this notice or hearing? <input type="checkbox"/> Yes <input type="checkbox"/> No <i>(If yes, see notice of final determination)</i></p>
<p>Section VI: Human Health</p> <p>A. Is the receiving water designated as a Public Water Supply? <input type="checkbox"/> Yes <input checked="" type="checkbox"/> No</p> <p>B. Applicable criteria affected by variance: No human health criteria for chloride</p> <p>C. Identify any expected impacts that the variance may have upon human health, and include any citations: None</p>
<p>Section VII A: Aquatic Life and Environmental Impact – Badfish Creek (Outfall 001)</p> <p>A. Aquatic life use designation of receiving water: Limited aquatic life @ outfall, Limited Forage Fish five miles below Oregon Branch, Warmwater sport fish community in Yahara River and Rock River</p> <p>B. Applicable criteria affected by variance: None, chronic toxicity criterion for chloride is 395 mg/L in all Wisconsin waters.</p> <p>C. Identify any environmental impacts to aquatic life expected to occur with this variance, and include any citations: Because there is no dilution available in Badfish Creek, the estimated instream concentration is equal to the proposed interim limit (465 mg/L in November – March, 430 mg/L in April - October). These concentrations exceed the applicable criterion of 395 mg/L. The proposed interim limits exceed the genus mean chronic values for <i>Ceriodaphnia</i> (417 mg/L).</p> <p>D. List any Endangered or Threatened species known or likely to occur within the affected area, and include any citations: None that would affect the water quality criterion, as the chronic toxicity criterion for chloride is more stringent than all genus mean chronic values for organisms with chloride toxicity data. As a result, no endangered species with data would need more protection than already provided by the existing criterion.</p> <p>Citation: U.S. Fish & Wildlife Service – Environmental Conservation Online System</p>

(<http://www.fws.gov/endangered/>) and National Heritage Index (<http://dnr.wi.gov/topic/nhi/>)

Section VII B: Aquatic Life and Environmental Impact – Badger Mill Creek (Outfall 005)

- A. Aquatic life use designation of receiving water:** Limited forage fish in Badger Mill Creek, coldwater community in the Sugar River.
- B. Applicable criteria affected by variance:** None, chronic toxicity criterion for chloride is 395 mg/L in all Wisconsin waters.

C. Identify any environmental impacts to aquatic life expected to occur with this variance, and include any citations:

Because there is no dilution available in Badger Mill Creek, the estimated instream concentration is equal to the proposed interim limit (465 mg/L in November – March, 430 mg/L in April - October). These concentrations exceed the applicable criterion of 395 mg/L. The proposed interim limits exceed the genus mean chronic values for *Ceriodaphnia* (417 mg/L).

D. List any Endangered or Threatened species known or likely to occur within the affected area and include any citations:

None that would affect the water quality criterion, as the chronic toxicity criterion for chloride is more stringent than all genus mean chronic values for organisms with chloride toxicity data. As a result, no endangered species with data would need more protection than already provided by the existing criterion.

Citation: U.S. Fish & Wildlife Service – Environmental Conservation Online System (<http://www.fws.gov/endangered/>) and National Heritage Index (<http://dnr.wi.gov/topic/nhi/>)

Section VIII: Economic Impact and Feasibility

A. Describe the permittee's current pollutant control technology in the treatment process:

Madison Met currently does not have any treatment capability for chloride.

B. What modifications would be necessary to comply with the current limits? Include any citations.

As described in more detail in the Chloride Compliance Study Report, treatment using reverse osmosis or electrodialysis reversal would be necessary to comply with the current limits. While lime softening was also evaluated as a treatment technology, MMSD determined that uncertainty related to removal of water softeners and infrastructure limitations related to ownership of drinking water infrastructure and the land necessary to build lime softening treatment made lime softening an infeasible technology at this time.

C. How long would it take to implement these changes?

Due to the environmental harm associated with these technologies, a timeline for implementation has not been established.

D. Estimate the capital cost (Citation): N/A – This variance is not based on economic hardship. Therefore, financial costs are not part of the documentation for this variance.

E. Estimate additional O & M cost (Citation): N/A

F. Estimate the impact of treatment on the effluent substance concentration, and include any citations:

The draft permit includes seasonal interim limits of 465 mg/L and 430 mg/L with a target value of 419 mg/L. This is a 2.6%-9.8% reduction in chloride discharged. To achieve the final water quality effluent-based limit of 395 mg/L, there would need to be an 8.1%-15% reduction in chloride discharged.

G. Identify any expected environmental impacts that would result from further treatment, and include any citations:

As summarized above and detailed in Simplified Triple Bottom Line analysis and Chloride Compliance Study Report, potential treatment options for MMSD would result in greater environmental harm than continuing to discharge at the LCA and implementing source reduction measures.

H. Is it technically and economically feasible for this permittee to modify the treatment process to reduce the level of the substance in the discharge? ☐ Yes ☐ No ☐ Unknown

As described in the submitted documentation, it may be technically feasible for the permittee to modify treatment to reduce the level of chloride but doing so would cause greater environmental harm than continued

discharge of chloride at current levels in addition to continued implementation of the facility's source reduction measures plan for chloride.

I. If treatment is possible, is it possible to comply with the limits on the substance? ☐ Yes ☐ No ☐ Unknown

As described in more detail in the Chloride Compliance Study Report, it is technologically possible to comply with the limits using RO or EDR.

J. If yes, what prevents this from being done? Include any citations.

All technologically feasible treatments would cause more environmental harm than continued discharge of effluent at the LCA in addition to continued implementation of the facility's source reduction measures plan for chloride.

K. List any alternatives to current practices that have been considered, and why they have been rejected as a course of action, including any citations:

As described in the AECOM Chloride Compliance Study Report the following technologies were evaluated; lime softening, electrodialysis reversal (EDR), and reverse osmosis (RO). All were rejected as a course of action either due to uncertainty of compliance (lime softening) or greater amounts of environmental harm from installing treatment than continued discharge at LCA (EDR, RO) and continued implementation of the facility's source reduction measures plan for chloride.

Section IX: Compliance with Water Quality Standards

A. Describe all activities that have been, and are being, conducted to reduce the discharge of the substance into the receiving stream. This may include existing treatments and controls, consumer education, promising centralized or remote treatment technologies, planned research, etc. Include any citations.

Madison Met has put forth considerable effort to educate the community as well as the contributing sanitary district and industries. MMSD focuses on two main contributors; water softeners and road salting. Madison Met's efforts were focused on a pilot project to evaluate potential incentive programs for replacement/tune up home softeners. In addition, Madison Met has developed an extensive public education system which is WiSaltWise.com which focuses on private road salting practices. Additional information has also been made available for general chloride reductions and can be found at <http://www.madsewer.org/Programs-Initiatives/Chloride-Reduction>. Further discussion can be found in the most recent annual report for 2016 actions. Actions going back to 2011 have also been included in annual reports.

B. Describe all actions that the permit requires the permittee to complete during the variance period to ensure reasonable progress towards attainment of the water quality standard. Include any citations.
From Madison Met's proposed permit:

3.2.1.9 & 3.2.2.6 Chloride Variance – Implement Source Reduction Measures

The permit contains a variance to the water quality-based effluent limit (WQBEL) for chloride granted in accordance with s. NR 106.83(2), Wis. Adm. Code. As conditions of this variance the permittee shall (a) maintain effluent quality at or below the interim effluent limitation specified in the table, (b) implement the chloride source reduction measures specified in the "Madison Metropolitan Sewerage District, Chloride Pollutant Minimization Program/Source Reduction Measures" plan and other supporting documentation, (c) perform the actions listed in the compliance schedule. (See the Schedules section of permit)

Submit annual chloride reduction progress reports (a total of four) indicating which chloride source reduction measures have been implemented and a calculated annual mass discharge of chloride. Also, submit a Final Chloride Report documenting the success in meeting the chloride target value of 419 mg/L.

Section X: Compliance with Previous Permit (Variance Reissuances Only)

A. Date of previous submittal:	<u>11/03/2009</u>	Date of EPA Approval:	<u>09/29/2010</u>
B. Previous Permit #:	<u>WI-0024597-08-0</u>	Previous WQSTS #:	<u>(EPA USE ONLY)</u>
C. Effluent substance concentration:	<u>377 mg/L (mean)</u>	Variance Limit:	<u>481 mg/L</u>
D. Target Value(s):	<u>430 mg/L</u>	Achieved?	<input checked="" type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Partial

E. For renewals, list previous steps that were to be completed. Show whether these steps have been completed in compliance with the terms of the previous variance permit. Attach additional sheets if necessary.	
Condition of Previous Variance	Compliance
Identify sources of chloride to the sewer system.	<input checked="" type="checkbox"/> Yes <input type="checkbox"/> No
Require significant industrial and commercial contributors to evaluate their chloride discharges and make recommendations for significantly reducing them, with the results of that evaluation being the basis for potential restrictions of chloride discharges.	<input checked="" type="checkbox"/> Yes <input type="checkbox"/> No
Educate homeowners on the impact of chloride from residential softeners, discuss options available for increasing softener salt efficiency, and request voluntary reductions.	<input checked="" type="checkbox"/> Yes <input type="checkbox"/> No
Recommend residential softener tune-ups on a voluntary basis.	<input checked="" type="checkbox"/> Yes <input type="checkbox"/> No
Request voluntary support from local water softening businesses in the efforts described in subds. 2. and 3.	<input checked="" type="checkbox"/> Yes <input type="checkbox"/> No
Educate licensed installers and self-installers of softeners on providing optional hard water for outside faucets for residences.	<input checked="" type="checkbox"/> Yes <input type="checkbox"/> No
Submit annual reports	<input checked="" type="checkbox"/> Yes <input type="checkbox"/> No
Meet interim limit of 481 mg/L.	<input checked="" type="checkbox"/> Yes <input type="checkbox"/> No

Attachment C – Pollutant Minimization Plan

**Madison Metropolitan Sewerage District
Chloride Pollutant Minimization Program/Source Reduction Measures
May 2017**

Section I: General Information

Name of Permittee: Madison Metropolitan Sewerage District, Nine Springs Wastewater Treatment Plant

Permit Number: WI 0024597

This is: The first permit issuance requiring implementation of a PMP/SRM.

Permit Effective Date: TBD

Date of First PMP/SRM: N/A

This variance is for: Chloride

Section II: Summary of Pollutant Reduction Work Done to Date

A. Pollutant Source Identification Efforts:

Since 2010, MMSD has focused on chloride source identification and source reduction. MMSD has worked to determine the sources of chloride that are tributary to the Nine Springs Wastewater Treatment Plant. The Chloride Compliance study completed by AECOM for MMSD in 2015 identified several chloride sources and proportional contributions of each source, summarized in the following table. MMSD will continue to refine these estimates through a variety of techniques.

Summary of Annual Average NSWTP Wastewater Chloride Contributions

Chloride Source	Annual Average Chloride Mass (lbs/day)	Annual Average Percent of Total
Background from potable water supply wells	11,491	8 %
Typical contribution from domestic wastewater	11,829	8 %
Zeolite water softener contribution	80,500	57 %
Industrial input	25,000	18%
NSWTP chemicals, septage and hauled waste	3,138	2 %
Road de-icing	10,000	7 %
TOTAL	141,958	100 %

To further define sources and specific areas to focus on, additional actions are being undertaken.

A. Pollutant Source Identification Efforts	Controllability and Learnings from Source Identification Effort	Date Started/Ended
Residential Water Softener Study	Partially controllable: while residential sources are not normally considered controllable sources, through our softening study, we found that residential water softeners contribute significantly to influent chloride and modification/replacement of these devices could impact chloride at the plant.	2013/2016
Develop mass balance of chloride sources	Some of the sources are controllable while others are not. See explanation below for comments on which sources are not considered controllable.	2013/2014
Industrial Monitoring and industrial baseline	Initial monitoring and surveys indicated a few significant contributors which MMSD continues to focus on. Significant reductions were made with Kraft Heinz and further reductions will be realized when their operations cease in 2017.	2012/2017
Evaluate MMSD sources	Some of the MMSD sources are controllable. MMSD continues to evaluate and optimize processes, chemicals and softening/water treatment systems.	2012–present
Pumping Station monitoring (by basin contribution)	This sampling helps us determine trends, effectiveness of intervention and focus areas.	2011-present
Sector surveys	These surveys help us determine baseline and focus areas. Future surveys will show the effectiveness of our interventions.	2011-present
Survey of road salt practices - MMSD customer communities	These surveys provide us baseline on the practices used throughout our basin. Future surveys will show the effectiveness of our interventions.	2014, 2017 and reoccurring

If any source is not controllable, please explain why.

The water supply in the area tributary to MMSD's Nine Springs Plant has very hard water (17-30 grains) and no source water softening is provided by local water utilities. Household water softener use is estimated to exceed 92% (study conducted by Madison Water Utility and MMSD). In our tributary basin, that approaches 100,000 individual household systems. Zeolite process with brine regeneration is the

only approved process by the State of Wisconsin. Salt-free devices are not approved for sale in Wisconsin (Wisconsin Department of Safety and Professional Services – plumbing). There is no current national certification/approval process for non-salt water conditioning devices. Because elimination of softening is not practical, efficiency improvements are required. New, efficient, softening systems cost around \$1000 per unit which is a barrier. Therefore, although water softener contributions are partially controllable, tools to control this chloride source are limited by current technology and policy constraints.

In addition, chloride concentrations appear to be increasing in many source water wells. This increase passes directly to and through the wastewater plant. MMSD has minimized the use of chloride-containing chemicals at the wastewater treatment plant. However, wastewater treatment processes balance a variety of objectives, and MMSD is unable to completely eliminate the use of chloride-containing chemicals without impacting effluent quality for other parameters. Finally, the weather confounds results between years. All other things being equal, chloride concentration is inversely related to flow. Dry years have less flow and thus higher concentrations. Although MMSD does not have combined sanitary and storm sewers; stormwater can enter the sanitary sewers through infiltration/inflow. In severe winters that significantly increase road salt use in our tributary basin, chloride loads to the Nine Springs Plant can increase due to inflow/infiltration of road salt-laden water.

B. Actions Identified to Minimize Pollutant Sources

The actions below will continue to evolve:

Action to Minimize Pollutant Sources	Action Implemented	Date
Optimize Chloride Use at Nine Springs Plant	Chemical use analysis and optimization	2012 & on-going
	Softener replacements	2013
	Softener optimizations	2014
	Emonix system installations	2017
Increase road salt awareness and change behavior/social norms.	Developed WiSaltWise.com	2014 & on-going
	Shovel, scatter, switch (poster and card outreach campaign)	2015
	Facebook, Twitter presence	2016
	Videos and Youtube channel rollout	2017 & on-going
Increase knowledge of system efficiency for softening system owner, operators, manager and	Developed, implemented and expanded water softening training program for facility	2016, 2017 and on-going

Action to Minimize Pollutant Sources	Action Implemented	Date
plumbers.	managers, water softener professionals and plumbers	
Motivate reductions in the amount of salt discharge by buildings that are tributary to MMSD's plant.	Developed, modified and expanded grant programs for salt reductions in facilities (commercial/industrial)	2015,2016, 2017 and ongoing
Increase industrial knowledge and encourage industrial practices that lead to less salt use.	Implemented salt discussions into annual industrial pretreatment inspections and action plans.	2011-present & on-going
Encourage action by large user relating to salt reduction	Industrial chloride permit issued	2014/2017 (industry will be shutting down operations)
Increase regional knowledge of Winter Maintenance Best Management Practices for reducing salt use.	Hosting yearly Winter Maintenance training	2014 & on-going
New softening systems are efficient and existing softening systems are set as efficiently as possible.	Work with the Water Quality Industry to develop and roll-out BMP's for softening systems	2011, revised in 2014
Expand the use of new winter maintenance equipment and practices that lead to less salt use	Road salt equipment grants to reduce barrier to adopting new practices.	2015, 2016 and on-going
Improve plumbing systems and softening systems to reduce building salt use.	Evaluate new/different technology/plumbing schemes that can help reduce chloride discharges to sewer. Evaluate barriers to adoption.	On-going
Reach customers at the point of softener purchase.	Work with Water Quality Professionals and develop outreach materials that lead to improved softener efficiency	2011 & on-going
Raise the bar for softening efficiency	Roll-out BMP's to water quality	2011, 2014 & on-going

Action to Minimize Pollutant Sources	Action Implemented	Date
	professionals, builders, plumbers and specifiers.	
Lack of understanding and social norms that do not align with 'right sizing' the local salt diet.	Test/expand behavior change initiatives	Pilot test in 2016, another test in 2017 & on-going

C. Actions Taken to Maintain Source Reduction

Maintenance of Source Reduction	Proposed Start Date	Responsible Party
Implement Sewer Use Ordinance Revisions including: 1. Requiring CMOM reporting information from customer communities (reducing inflow to sewer system) 2. Chloride information from wells (documenting the source water chloride contribution) 3. Allows MMSD to issue BMP oriented General Permits (chloride)	2015	MMSD Staff/Customer Communities
Wastewater monitoring of pumping stations (chloride and/or conductivity)	On-going	MMSD Staff
Industrial pretreatment inspections	On-going	MMSD Staff
Development of outreach for BMP for softening systems	2015	MMSD Staff/Industry partners
Surveys: road salt/softening/sectors	On-going	MMSD Staff
Permit driven compliance with major discharger	2015	MMSD Staff
On-going staffing and budget to support Chloride Source Reduction Program	2015	MMSD Staff

Maintenance of Source Reduction	Proposed Start Date	Responsible Party
Increase communications and behavior change programs: update website, create videos, develop outreach materials`	2011 & on-going	MMSD Staff
Continuing data mining, sampling/monitoring and analysis to maintain focus in correct areas.	2011 & on-going	MMSD Staff

Section III: Summary of Progress and Barriers to PMP Effectiveness

Average Pollutant Concentration in Previous Year: 407 mg/l (2015)

Average Pollutant Concentration this year: 382 mg/l (2016)

Please attach a graph of the variance pollutant concentration data over the last five years:

See Attachment A.

Have you encountered any barriers that have limited pollutant minimization program/source reduction measure effectiveness? Yes, the weather impacts chloride concentration as well as mass. Concentrations are dependent on the actual flow. Severe winters lead to additional application of road salt, some of which ends up in the wastewater. The road salt that does not end up in the wastewater impacts other water. Some of the road salt ends up in the drinking water, which also ends up coming to and through the wastewater plant as an uncontrollable source. In addition, water conservation measures camouflage results of salt reduction by residents and commercial, industrial users – that is, if flow decreases proportional to a reduction in chloride mass, then the concentration will stay the same despite the mass reduction. Attachment A includes a graph showing the inverse relationship between flow and concentration as well as the seasonal variation in chloride concentration.

If so, what adjustments will you make to the program during the next year to help address these barriers? Road salt impacts all waters of the state. The salt that does not arrive at a wastewater treatment plant ends up in groundwater, lakes, rivers, wetlands and/or drinking water. Locally, Dane County has hired a consultant to convene a team of applicators to develop Wisconsin based road salt application rates for low-speed roadways and parking lots. The City of Madison is developing a voluntary certification program for road salt applicators and plans to have that available by the end of 2017. MMSD aims to incorporate these practices into training for our customer communities and others applying road salt in our basin. The waters of Wisconsin would be most helped with a statewide approach to address and improve the use of road salt.

Salt-less softening technologies exist and appear to be successfully used throughout the world. Wisconsin's Department of Safety and Professional Services does not currently allow these systems to be considered for residential use. Our understanding is that Wisconsin is the only state with this requirement. With the known risk of chloride use on Wisconsin's water and the number of chloride variances in the State, we greatly appreciate DNR evaluating a solution to this barrier.

Section IV: Planned Actions

MMSD worked to develop and secure staff resources and the budget needed to implement a chloride reduction strategy focused on source reduction and pollution prevention. This strategy involves investment in non-traditional areas including rebates and incentives as well as education and training focused on changing social norms and behavior. Specific actions are included below:

A. Pollutant Source Identification Efforts	Proposed Start Date	Responsible Party
Pump Station Monitoring: Evaluate geographic distribution and peaking throughout the system by monitoring pumping station samples for chloride.	On-going	MMSD Staff
User Charge Sampling: Analyze user Charge Program samples for chloride. Evaluate the viability of adding chloride as a billing parameter.	2019	MMSD Staff
Road Salt Practices: Evaluate the current status and improvements through a re-survey of customer communities.	2017 and on-going	MMSD Staff
Baseline social-science survey: Study existing sources of chloride, and gather information specifically for development of future outreach strategies; measure awareness and attitudes; collect information about barriers to homeowner action through scientific survey.	2017/2018	MMSD Staff and possible consultant

B. Actions to Minimize Pollutant Sources	Proposed Start Date	Responsible Party
Administer training programs: SaltWise Soft Water Training; Winter Maintenance Training and develop/roll-out homeowner information and training program.	2017 & ongoing	MMSD Staff
Offer and expand salt-reduction rebate programs: simplify administration/ quantification for programs; continue 'commercial/ industrial' rebate program; continue 'professional' grant program; evaluate new or expanded programs to target specific markets.	2015 & ongoing	MMSD Staff
Offer Road Salt Equipment Grants: Target private and municipal operations; Incentivize salt-reducing innovations and develop leaders in the 'new normal;' measure change in winter maintenance policy & practices through follow up to 2014 & 15 surveys.	2015 & on-going	MMSD Staff
Behavior Change Initiatives: Develop programs to change behavior/social norms with businesses and individuals; leverage WiSaltWise to change behavior and social norms.	2018	MMSD Staff
Capitalize on low-hanging fruit: Develop outreach kit; focus industrial contacts on chloride reduction opportunities; attend community events as appropriate, with emphasis on chloride information.	Various actions start during 2017-2019	MMSD Staff
Expand digital presence: expand WiSaltWise.com/campaign and web resources (MMSD website, social media, videos)	Summer/Fall 2015 – On-going	Consortium/MMSD Staff

C. Maintenance of Source Reduction	Proposed Start Date	Responsible Party
Quantifications/Data Mining: analyze historic data; determine magnitude of previous reductions; develop estimates of and future viability.	2017	MMSD Staff
Lay groundwork for new construction/wholesale market program: (with significant growth of business and housing, new softening systems continue to be installed.) Evaluate market and potential entry points; gather information specifically for development of future outreach and/or incentive strategies.	2017/2018	MMSD Staff
Cultivate relationships/leverage partnerships: leverage existing social networks, build new relationships with hotels/apartments/industry; continue to facilitate conversations between salt reduction champions and their peers; partner with sustainability focused programs in the region to identify and leverage synergies and speak in venues where our messages can reach broad audiences.	2017	MMSD Staff
Communications: Develop and roll out videos/case studies and industry/large water user focused messages; target outreach and develop messaging.	2017	MMSD Staff
Funding and staffing: maintain on-going staffing and budget to support Chloride Source Reduction Program	Yearly	MMSD Staff, Ecosystem Services Director and Chief Engineer/Director

Section V: Notes

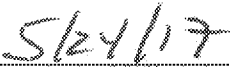
Please make any additional notes here. Attach additional pages if necessary.

Section VI: Certification

I certify that the information contained in this document and all attachments were gathered and prepared under my supervision and based on inquiry of people directly under my supervision and that, to the best of my knowledge, the information is true, accurate and complete.



David S. Taylor, Director of Ecosystem Services



Date

Attachment A - MMSD Nine Springs Chloride Concentration and Mass

The graphs below show the successes and challenges of chloride source reduction. Chloride concentration reflects the amount of chloride as well as the amount of diluting water. Water conservation measures reduce water use and lead to more concentrated effluent. Lighter winters, with less road salt use (like 2016), tend to have less mass in chloride. High flow years (like 2013), tend to have lower concentrations. Figure 1 shows the historic chloride concentration at MMSD's Nine Springs Plant.

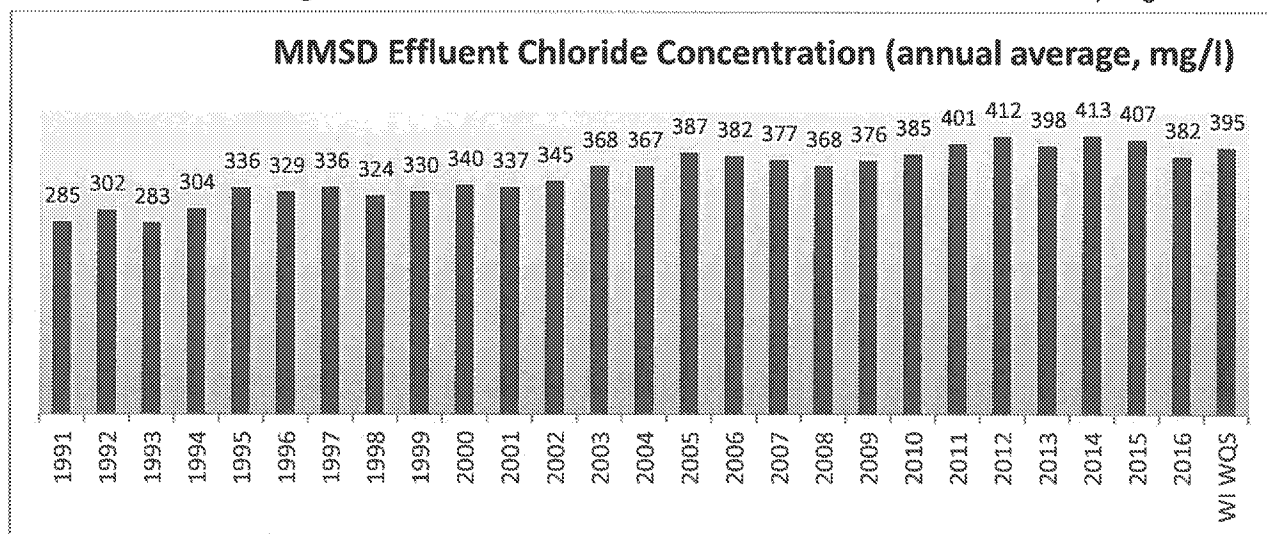


Figure 1

Figure 2 shows the weekly average concentrations for the time period of 2010 through 2016. There is significant variability throughout the year but each year follows a similar path. Early in the year, road salt is applied and some of that reaches the sewer system during a lower flow period of the year, resulting in higher concentrations. This graph illustrates the challenges and weather dependency of many chloride reduction interventions. It is encouraging that for large portions of the year, concentrations meet the water quality standard.

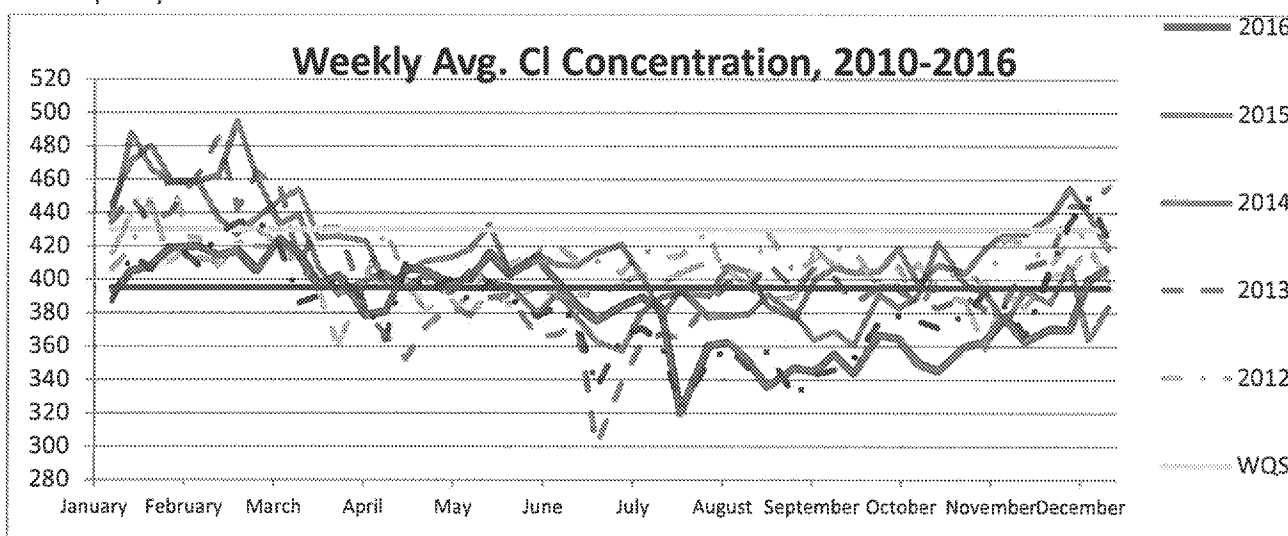


Figure 2

MMSD's Chloride Source Reduction program has been operating since October, 2010. Since this time, the trend line for chloride mass has reversed (Figure 3). This is even more encouraging because this period of time has realized significant growth (and additional soft water systems and roadways) in our tributary basin.

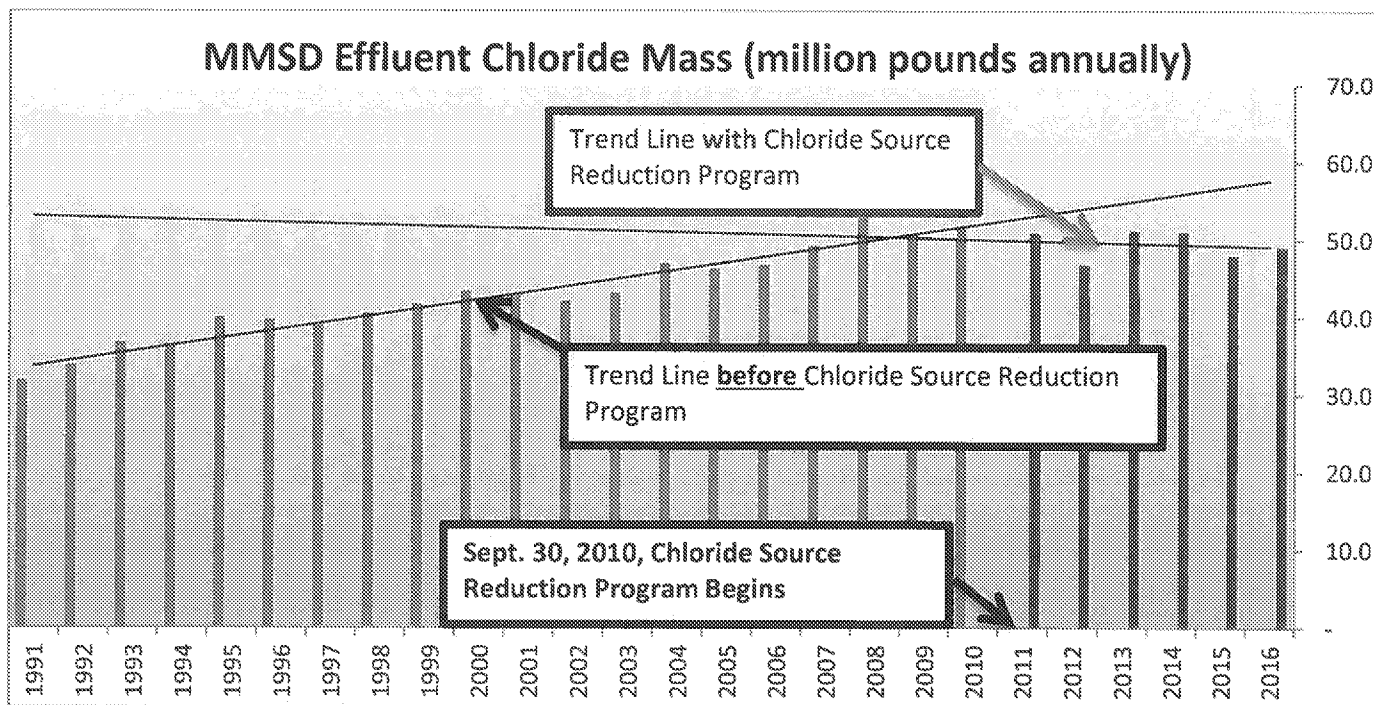
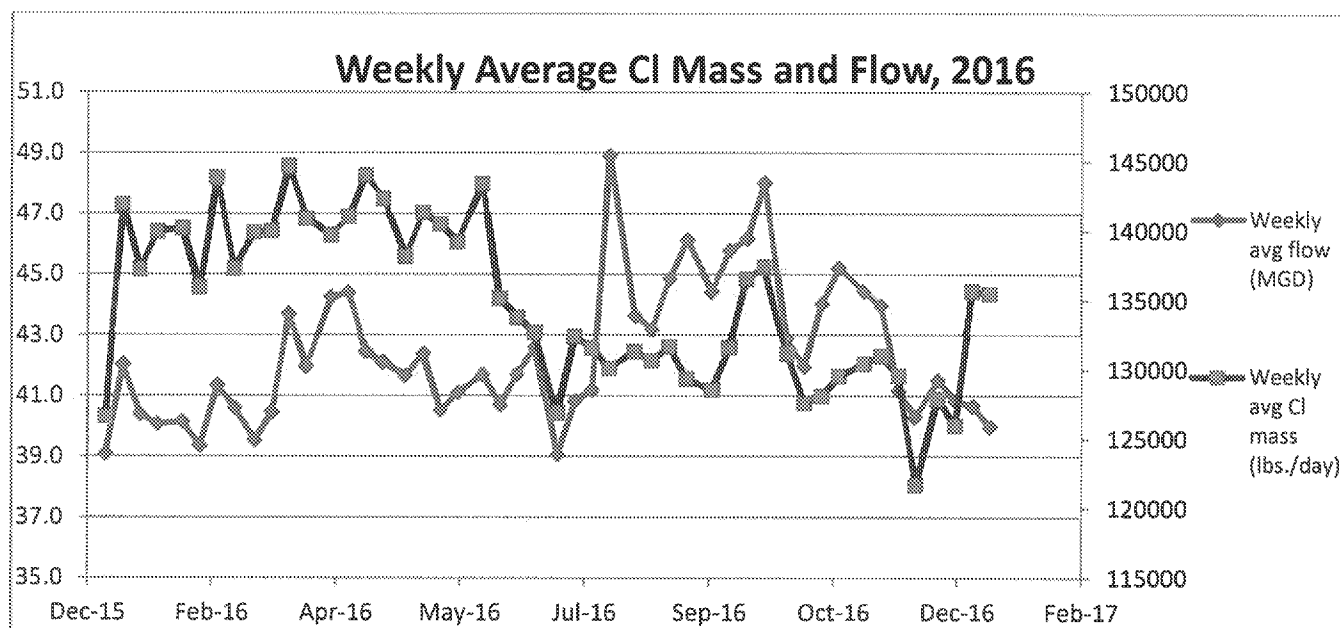


Figure 3

Figure 4 shows 2016 weekly average mass and flow data. When flows are high, concentrations come down significantly. This graph shows that the mass of chloride decreases in non-road salt months.



Attachment C.2 – Addendum to Pollutant Minimization Plan

**Madison Metropolitan Sewerage District
Water Softening Source Reduction Initiatives**

2018-2023

Goal	Tasks	Commentary	Timeline
Develop a larger pool of professionals knowledgeable in water softener optimization	Develop and deploy a technical training class focused on 'nuts and bolts' mechanics of softeners.	We continue to analyze data from our existing grant programs to estimate reductions based on various interventions. Optimization of household softeners proves to be a more cost-effective strategy than replacing household softeners with new ones. There is a need for professionals, as opposed to individuals to do work on softeners; optimizing them is very difficult for even experienced personnel because each appliance is different, each use/household is different and there are a variety of settings available for use. Professionals are not in agreement about how to do an optimization, and there are differences in methodology that have significant impacts on outcomes. MMSD has already offered training once, and already has approved DSPS continuing education credits for plumbers for this course. Staff are also currently working with a variety of professionals and other partners, such as WQA and Waukesha, WI, that is working on a similar program, to develop the information needed to make optimizations easier. Furthermore, having a pool of people who have been through an MMSD-provided training makes it easier for MMSD to make recommendations to homeowners who want to do the right thing, by being able to refer them to a professional.	Technical training is expected to be held in 2018 and expected to continue yearly.
Simplify messaging for homeowners	Evaluate barriers to homeowner action, identify opportunities, make a list of approved professionals available (through above mentioned training), provide further understand baseline knowledge, messaging information about softener at no cost (through incentive program/app development, see below), continue to develop synergies with WI Salt Wise website resources, and further work with partners to identify further information opportunities	There is no standard packaging/advertising that gives an average consumer any way to differentiate systems. In addition, we are working with industry professionals on ways to make new purchases more intuitive.	This work started before 2018. We intend to use the 2018 technical training to test messages and roll these out and refine them in 2019-2020 and continue the programs through 2023.
Communicate the causes and impacts of chloride to stimulate urgent action.	Encourage state and national agencies to develop resources and guidance that will help wastewater treatment plants be successful in reducing chloride. Provide municipal customers resources for community led source reduction initiatives. Meet with customer communities individually. Continue public outreach through MMSD's Shop One education center at the plant and existing tour program.	Salt is toxic in freshwater. Salt is being applied to drain directly into freshwater resources. There are no restrictions against its use. The only entities that are being asked to do something about this are the point source dischargers - the wastewater treatment plants. This does not lead to credibility and slows progress. The messaging relating to "WHY" anyone should change is challenging when our state does not have any resources available relating to chloride except "variances." We have worked with WQA to develop a calculator which illuminates the impact of the softener/softener efficiency on water quality.	An all customer chloride-focused meeting is scheduled for September 2018, and newsletter & direct meeting outreach to customers will be ongoing through 2023, as will general individual level outreach (tours & Shop One Education activities). MMSD continues to elevate the need for higher level leadership with the state as well EPA. We are hopeful that they will move forward prior to 2020.
Standardize water softener optimization tasks	Work with experts to develop a tool (app) to guide technicians and plumbers during softener optimizations, deploy this tool as part of the technical training classes, and tie an incentive to this tool.	This application will walk trained professionals through a standardized optimization method, wherein home water softeners will become more efficient, homeowners will be given information about their softener, and MMSD will be able to collect data about the amount of chloride reduced as a result of this program. The goal is that this digital application will be used to optimize softening systems and that the data input will be used by MMSD to document reductions. MMSD aims to tie an incentive program to use of the application - for example: if you attend training, you can use the tool to optimize a home system, if you do that and input the data, you get a rebate.	This work started before 2018. The 2018 technical training will help refine and test the messaging and information. Our goal is to have this information available for businesses and/or consumers in 2020.

Use trusted messengers to further chloride reductions	Continue to identify messengers, speak in venues to reach these messengers, continue pass-through incentive programs	As a metropolitan sewerage district, we do not have the same relationship with the end consumer as other municipalities (generally, they do not know who we are as individuals get bills from their communities water or sewer department and not from us.) Many water quality professionals, plumbers, engineers and architects, home inspectors etc. routinely work with various businesses and individuals, and as such, have relationships established. By leveraging existing trusted relationships, we have found individuals, businesses and industries more receptive to trying new ideas and/or changing practices. Our professional grant program, has been a demonstration that this tactic works; household softeners are being optimized and replaced (941 during the 2016-17 grant cycle). We continue to gather data from these programs, which we are using to develop our digital application for use by trusted messengers, other agencies, companies and individuals who can significantly improve the efficiency of existing softening systems.	This work started before 2018. The 2018 technical training and optimization tool will develop additional messengers to further these initiatives. This is a cornerstone of our source reduction program and work in this area will continue through 2023.
Incentivize new groups to leverage existing client relationships to reach a broad audience of homeowners	Develop incentive program tied to application (optimization tool) use and technical training	By leveraging existing trusted relationships, we have found businesses and industries more receptive to trying new ideas and/or changing practices. Working to educate the trusted messengers has multi-fold benefits.	Development commencing in 2018, expected to launch in 2019 with updated grant program.
Cap chloride contributions from new sources	Improve efficiency of new construction's softening	The goal is that all new units (or neighborhoods) will contribute less than the water quality criterion (395 mg/l) of chloride to the sewer system. This may be individually or on average. We are currently working with the largest and one of the most innovative developers as well as the Madison Area Builders Association. We are working to change business practices with regard to water softening. Our goal is that new homes and businesses have softening systems that use salt more efficiently than the current water quality criterion. Therefore, any additions to the system will not be negatively impacting our chloride reduction goal.	We aim to identify the best means through which to enact change in this arena. Research with partner organizations should yield a clear path forward. We are working directly with two organizations to develop at least one Innovation Grant focused on this action by 2020.
Continue to reduce chloride from industrial sources	Continue incorporation of chloride parameter in monitoring reports, source reduction requirements on permits, and incentive opportunity discussion during annual inspections. Look to permit larger users within the pretreatment program, under a general permit	Currently permitted industrial sewer users have made large improvements under their permit requirements in their chloride discharge. This has been shown to be an effective method of working with industry, however the district has yet to expand use of the permit to any users that are not SIU or CIU. District staff continue to assess large salt users and evaluate the potential to use regulatory drivers, if needed, to encourage action. To date, industries are responding without regulation - seeing significant payback to salt-reducing activities. The case studies for Pfizer and Hydrite are good examples (search salt reduction resources on www.madsewer.org).	Ongoing work through 2023 as needed.
Improve specifications for water treatment equipment to promote reduced salt use	Using MMSD's existing BMPs as well as the recently revised WI Department of Administration specification as starting points, continue to reach out to engineers, plumbers, architects and other relevant parties to develop more efficient specifications and develop case studies that justify saltless technologies.	Larger facilities have many options for water treatment. Softening systems have historically been used without significant thought and/or design. Through the chloride source reduction program, we have found that the payback period for brine reclaim is relatively short for larger water users; we have found saltless technologies work for various applications; we have found success when industries treat water for the actual use versus treating all their water (i.e.: polishing softeners ahead of critical equipment) and that only the water that needs to be softened is softened.	MMSD is convening meetings with ASRAE's local leadership to talk about overall improvement of softening specifications among their members. We anticipate the majority of specifications used in our region to reflect higher attention to water softening by 2020.
Continue to assess baseline knowledge	Use best tools (such as surveys, focus groups, outreach, other feedback mechanisms) to gather information specifically for development of future outreach strategies; pilot outreach	Understanding existing knowledge about softeners is an essential prerequisite to producing effective education that fills gaps. In Wisconsin, over 60 wastewater treatment plants have chloride variances. In addition, chloride has become significant in our adjacent states of Minnesota and Illinois. There are a variety of professionals whose livelihoods are tied to softening and/or salt. Pooling resources and sharing findings will have impacts beyond just MMSD's service area.	We plan to collect baseline information to inform future programming and will evaluate repeat efforts in the future.

Encourage innovation	Provide incentive, support for projects that push traditional boundaries	Many innovations could help move our chloride program forward. Saltless technologies have been used to reduce scale in various commercial and industrial applications (without the need for salt). Economies of scale and other barriers, however, prevent these approaches from working as well in small-scale softening applications, like that of a home. The district estimates over 100,000 water softeners, discharging on average a half a pound of chloride/day, are tributary to the treatment plant. As the district's service area expands, and areas continue to develop, this number is expected to continually grow. Given the high cost per pound reduction associated with upgrading home-sized softeners, lack of homeowner awareness/capabilities, and the long life cycle of home softeners, the district would like to encourage exploration of alternative scenarios.	MMSD continues to be a leader and has helped a variety of agencies and organizations move forward with initiatives aimed at changing how they approach salt use. We expect to continue this work through 2023.
Influence code & regulation changes	Evaluate the need and viability of code and regulation changes and define paths to successfully change policy and regulations to streamline chloride reductions.	Our understanding is that Wisconsin is the only state in the US that does not allow saltless scale reducing technologies to be used in residential water treatment systems. In addition, the current plumbing code leads to oversizing of plumbing systems which can reduce the efficiency of softening systems. The only codes that MMSD directly controls are our sewer use ordinance. While we are investigating the possibility of softening requirements specific to our service area, we receive chloride from outside our service area through our hauled waste program and are aware of competitive challenges to local and national businesses with a variety of requirements. We are monitoring the Virginia Tech study looking at the efficiency of various saltless technologies. We are working with manufacturers to get their equipment tested and those results provided to Wisconsin's Department of Safety and Professional Services (DSPS).	This work has been ongoing since MMSD's chloride source reduction program began. We continue to evaluate viable pathways. The saltless scale removal study at Virginia Tech was originally due to be complete in 2017 and has been delayed. Once complete, that may be the information needed for WI's plumbing code to be modified.
Develop, maintain partnerships	Periodic meetings, phone calls, training programs, facilitated conversations, incentive programs	We are working with a variety of partners to optimize salt use to meet our permit requirements. MMSD's BMPs have changed the business practices for local water quality companies. This is also quite evident in our work on road salt. Because of MMSD's source reduction program, Wisconsin now has state standards for road salt application on low speed road, parking lots and sidewalks and a certification program for applicators as well as the WISaltWise outreach and education program. Through our partnerships, we envision the overall efficiency of the softening stock in the state to be increased. Already, some manufacturers are only selling higher efficiency equipment and others have stopped sending out equipment with factory settings (historically very inefficient).	One of the first tasks of our chloride source reduction program was to bring the water quality professionals together. We continue to work with this group and others to change business practices and improve the overall efficiency of softening systems. The technical training is expected to increase this group.
Stimulate research and development	Work with industry affiliates, university, peer organizations, private researchers the best means through which effective, independent research can be produced to further long term sustainability in MMSD's chloride reduction initiative	Research which evaluates & expands the options for salt-free or discharge-free water treatment systems, that which lessens the impacts associated with hard water, and that which reduces the demand for softened water can fundamentally upset the current status-quo of the current softener paradigm. Examples of this could include fixtures that work with hard water; coatings that keep scale from forming or allow it to be easily removed; saltless technologies that protect users from the impacts of hard water; right-sizing plumbing systems (reducing demand for soft water) and brine reuse opportunities.	This program is expected to pilot in 2019. We are currently working with a variety of researchers and other research funding programs to develop this program.
Increase efficiency of existing large salt use softeners (hundreds of pounds per month use)	Continue to offer rebate program	In 2017 alone, the 13 rebate awards are estimated to reduce 346 pounds per day of chloride - over 200,000 pounds per year of salt. MMSD's rebate and incentive programs are able to be refined and modified based on the specific needs. We have made yearly improvements to this program since its inception. We have worked with industry professionals and others to continually improve the program. The rebate program allow individual businesses to apply for rebate to improve water quality equipment or reduce salt discharge in other ways. The Water Quality Professional Grant program allows companies to apply for grants to work with their customers on salt saving projects. These programs enter the supply chain in different places and using different methods to reach potential salt savings.	Incentive programs have been used by MMSD since 2015. These grants continue to evolve, and are flexible to shift focus if the district's analysis determines that funds have greater efficacy elsewhere. We expect these programs to continue through 2023.

Attachment D – Simplified Triple Bottom Line

Chloride Compliance – Simplified Triple Bottom Line Comparison

Nine Springs Wastewater Treatment Plant

Madison Metropolitan Sewerage District

Madison Metropolitan Sewerage District (MMSD) receives wastewater from the greater Madison area. MMSD's Nine Springs Wastewater Treatment plant (NSWTP) is not designed to remove chloride. Therefore, any chloride arriving at the plant leaves in the reclaimed resources (effluent and biosolids). In 2015, MMSD commissioned a study to assess feasible chloride treatment options to bring the NSWTP effluent into compliance with Wisconsin's chloride water quality standard. AECOM produced the "Chloride Compliance Study Nine Springs Wastewater Treatment Plant" (study). This study assesses feasibility, develops concept level costs and assesses triple-bottom line considerations for each evaluated treatment option. The entire study is available on the district's website (visit www.madsewer.org and search "chloride compliance study"). While complete information is included in the study, a simplified triple-bottom line assessment is attached to this document. Further information on the options included in that assessment are detailed below.

Two of the options evaluated in the study involve treating a portion of the NSWTP effluent to remove chloride. Since NSWTP's effluent nearly meets compliance with permit limits for chloride, the volume of wastewater that would need to be treated to routinely bring the effluent into compliance with the water quality standard is very small. It is estimated that during current average flow conditions, 2.6 MGD of NSWTP's approximately 42 MGD would need chloride removed to achieve compliance. In the study, the future average design flow used for design development is 7.3 MGD while the maximum flow used for the design is 15 MGD. While treating for chloride would remove other constituents from the water, the relatively small portion of water treated minimizes the ancillary benefits. For example, removing chloride may lead to a small phosphorus reduction, but only in the treated portion. At today's average flow conditions, chloride treatment technology may result in a 6% reduction in effluent phosphorus – far from the 70% reduction needed to meet compliance with the water quality standard. Similarly, any incidental reduction in effluent mercury as a result of chloride treatment would depend on the distribution of mercury in the wastewater, which would be out of MMSD's control at the plant. If sediment-associated mercury did not pass through the chloride removal stream, that mercury would not be removed through chloride treatment. Ultimately, any constituent removed from the wastewater will remain in the concentrated brine and thus remain in the environment.

The study assesses two technological options to remove chloride from wastewater:

- Option 2A-C – Reverse Osmosis (RO)
- Option 3A-C – Electrodialysis Reversal (EDR)

A significant disadvantage of RO or EDR treatment processes is the large volume of concentrated brine generated as a result of treatment. The different letters within each number option refer to different methods of handling and disposing of the resultant brine waste from each technology. At design flow rate, the amount of brine waste generated is expected to be 1.5 million gallons per day. An evaporation

process can be used to reduce the volume of brine by approximately 90%, adding to that a crystallization process can reduce the brine waste to a solid form.

Each of the wastewater treatment options assessed includes various levels of brine minimization. Options 2A and 3A include hauling away liquid brine (“the removal treatment”). The remaining treatment options build on options 2A or 3A by adding treatment to reduce the volume of brine generated. Options 2B and 3B add evaporation to the removal treatment to reduce the volume of brine that needs to be hauled away, while Option 2C and 3C add both evaporation and crystallization after the applicable removal treatment. Options 2A, 2B, and 2C are very similar in cost and environmental impact to options 3A, 3B and 3C. Therefore, the assessment below shows one of the options (reverse osmosis treatment, 2A) as well as this option with the most extreme brine minimization (evaporation and crystallization, 2C).

The study also includes three source reduction opportunities which make up parts of MMSD’s chloride source reduction program. These are included in the attached Triple-Bottom Line assessment and assessed collectively:

- SR6 – Industrial/commercial source reduction (working with sources to reduce their chloride discharges to the sewer system)
- SR7 – Educate residential customers and/or control the use of residential water softeners
- SR8 – Convert to use of higher efficiency softeners

The study also includes two treatment options that would involve treating drinking water at the source to remove hardness (1A and 1B). These options are not included in the table on the next page. Approximately sixty municipal drinking water wells are tributary to the NSWTP. None of these wells are owned, operated or controlled by MMSD. Options 1A and 1B were cursorily assessed, but major costs (including land purchase) and constraints (including the fact that many of the existing wells lack space to add treatment) were not included. In addition, the actual reduction in chloride is dependent on each individual homeowner and/or business removing their softening system and no costs have been included to accomplish this. Even with these caveats, the 20-year present worth cost of options 1A and 1B are similar to the lowest cost treatment options at NSWTP.

Finally, the Simplified Triple Bottom Line assessment compares the options above to a ‘no action’ option.

The assessment on the next page is a simplified assessment of more complete information found in the study, which can be found on Madison Metropolitan Sewerage District’s website:

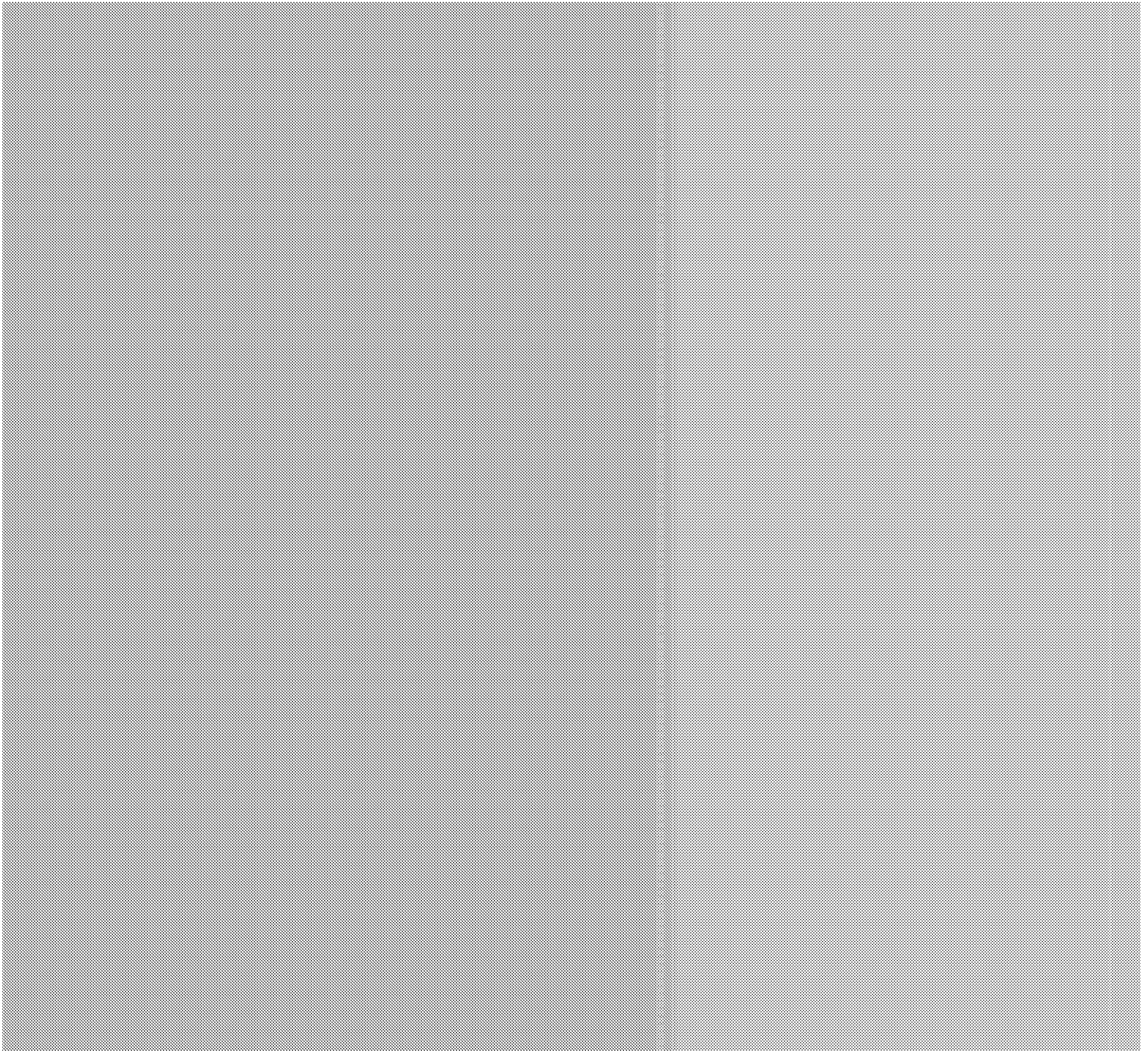
<http://www.madsewer.org/Portals/0/ProgramInitiatives/ChlorideReduction/MMSD%20Chloride%20Compliance%20Study%20Report%20-%20Final%206-19-15bookmarks.pdf>

Simplified Triple Bottom Line Assessment – NSWTP Chloride Compliance

	2A (RO without brine minimization)	2C (RO with brine minimization)	SR-6	SR-7	SR-8	No Action
Meet water quality standard	Yes	Yes	Yes			Not always
Financial & Operational	Capital Cost \$87,000,000 Operating \$136,800,000/yr	Capital Cost \$193,000,000 Operating \$15,400,000/yr	\$1,000,000			No change
20-yr present worth	\$2,300,000,000	\$460,000,000	\$850,000			No change
Avoided costs/new revenues	Minimal	Minimal	\$400 million to \$2.3 billion			\$400 million to \$2.3 billion
Complexity of processes	Medium	Medium	Medium			Low
Operational risk	Medium	Medium	Low			Low
Plant Total Energy Use	Add: 8,500 MWh/yr	Add: 80,000,000 MWh/yr	No change			No change
Plant Carbon Footprint	Add: 16,500 metric tons CO2e/yr	Add: 46,500 metric tons CO2e/yr	No change			No change
Speed	Planning, design and construction could take 3-5 years	Planning, design and construction could take 3-5 years	Ongoing, up to 10-years.			Immediate
Public Acceptance Factors	Negative, high costs and environmental impact for minimal indistinguishable change in water quality. Significant number of truck trips (146/day) and hauling (estimated at 21,900,000 miles/yr) to remove liquid waste brine for dispose.	Negative, high costs and environmental impact for minimal, indistinguishable change in water quality. Solid brine waste remains in the environment.	Success requires individuals to change behaviors and adjust social norms. Improvements to softening may unequally impact various businesses and homeowners. Successful program protects environment and rate payers from increased costs.			None anticipated. Current yearly average chloride is currently under the water quality standard. Weekly average concentrations exceed the WQS for a few weeks each year during a time of significant road salt runoff.

Attachment E – Excerpts from Chloride Compliance Study Report

Chloride Compliance Study Nine Springs Wastewater Treatment Plant Final Report



Executive Summary

The Madison Metropolitan Sewerage District (District) Nine Springs Wastewater Treatment Plant (NSWTP) provides treatment of wastewater collected from the Madison metropolitan area. The District is a special purpose government agency as defined by the State of Wisconsin Statute 200, and is governed by a 5-member commission.

Increasingly stringent effluent limits for chloride are expected to be enforced for the NSWTP in the future by the Wisconsin Department of Natural Resources (WDNR). The Wisconsin Pollutant Discharge Elimination System (WPDES) permit for the NSWTP contains a variance to the water quality standard for chloride, but includes several conditions relative to the variance. These conditions include meeting interim effluent limits for chloride, and implementing source reduction measures to reduce the chloride load to the NSWTP. However, it is expected that the interim chloride limits for the NSWTP will be reduced in future permits with the ultimate goal of meeting the Water Quality Based Effluent Limit (WQBEL). Since the effluent receiving streams, Badger Mill Creek and Badfish Creek, provide minimal dilution of the NSWTP effluent, the future chloride limits are expected to reflect the WQBEL of 395 mg/L on a weekly average basis. The District has therefore undertaken this study to identify and rank alternatives for compliance at the NSWTP with the future chloride WQBEL.

Several technology options were identified to minimize the discharge of chloride to the NSWTP, and to provide removal of chloride from the effluent of the NSWTP. Technology options were then selected and grouped to form alternatives for further development and evaluation. AECOM completed a Triple Bottom Line (TBL) analysis in conjunction with the District's technical team to select technology options and to rank alternatives developed from the technology options. The TBL determination of project 'value' is carried out through a system of measurement that has two main elements:

- * Indicators that are designed to measure certain attributes of value
- * A rating system that applies a consistent set of rules to normalize, interpret, classify, aggregate and represent the measure indicator values to make them useful for decision-making.

AECOM's TBL tool compares proposed alternatives across three different categories:

- * Financial and operational – compares financial impact to project and operational considerations
- * Environmental – compares impacts on local environment
- * Social and community – compares impacts and risks on local residents and their acceptance of proposed strategies as well as the project's role in shaping the District's image as a leader in innovative environmental technologies

Each category is made up of multiple criteria, built upon measurable indicators. AECOM worked with the District review team to select and define the criteria used in the TBL analysis. Selected criteria and the scoring system are described in Section 4.0.

Mass balances were constructed to estimate the sources and fate of chloride at the NSWTP for the current and future design conditions. A future design year of 2030 was selected to provide consistency with the District's other capital planning work. A summary of the mass balance scenarios is provided below. Details of the mass balances are provided in Figures 2-1 through 2-6.

Summary of Chloride Mass Balance Scenarios

Figure	Influent Flow Rate	Influent Chloride Load	Effluent Chloride Load
2-1	Current annual average (40.50 MGD)	Current annual average 140,000 lbs/day (414 mg/L)	141,958 lbs/day (420 mg/L)
2-2	Current annual average (40.50 MGD)	Current maximum day 169,400 lbs/day (502 mg/L)	170,958 lbs/day (509 mg/L)
2-3	Current maximum day (56.70 MGD)	Current maximum day 169,400 lbs/day (358 mg/L)	171,303 lbs/day (363 mg/L)
2-4	2030 annual average (44.55 MGD)	2030 annual average 169,400 lbs/day (456 mg/L)	173,050 lbs/day (466 mg/L)
2-5	2030 annual average (44.55 MGD)	2030 maximum day 204,974 lbs/day (552 mg/L)	206,883 lbs/day (562 mg/L)
2-6	2030 maximum day (62.37 MGD)	2030 maximum day 204,974 lbs/day (394 mg/L)	207,546 lbs/day (402 mg/L)

The evaluation of chloride sources to the NSWTP revealed that chloride contributed as a result of the use of zeolite water softeners by the District's residential, commercial and industrial customers is the most significant source, contributing an estimated 57% of the total chloride load on an annual average basis. Zeolite water softeners contribute chloride to the NSWTP as a result of the salt that is used to regenerate the zeolite resin. Also significant is the discharge of chloride by industrial customers, contributing an estimated 18% of the total load on an annual average basis. A summary of the annual average chloride contributions to the NSWTP is provided below. It should be noted that the relative chloride contributions may vary seasonally, largely due to the impacts of road de-icing which takes place during cold weather months.

Summary of Annual Average NSWTP Wastewater Chloride Contributions

Chloride Source	Annual Average Chloride Mass (lbs/day)	Annual Average Percent of Total
Background from potable water supply wells	11,491	8 %
Typical contribution from domestic wastewater	11,829	8 %
Zeolite water softener contribution	80,500	57 %
Industrial input	25,000	18%
NSWTP chemicals, septage and hauled waste	3,138	2 %
Road de-icing	10,000	7 %
TOTAL	141,958	100 %

A number of technology options were identified to eliminate the need for use of zeolite softeners, and to provide treatment for removal of chloride at the NSWTP. Additional technology options were identified to address the waste residuals that would be generated as a result of chloride treatment. The technology options are summarized below.

- ※ Source reduction options
 - ※ Reducing chloride concentrations in well water supplies
 - ※ Softening of well water supplies to eliminate need for residential zeolite softeners
 - ※ Reducing chloride load from industrial/commercial sources and zeolite softeners
- ※ Chloride Treatment at NSWTP
 - ※ Minimize or eliminate chemicals that contribute chloride at NSWTP
 - ※ Treatment of NSWTP effluent to remove chloride
 - Reverse osmosis
 - Electrodialysis reversal
 - Ion exchange
 - ※ Brine minimization
 - Microfiltration/reverse osmosis
 - Softening followed by microfiltration/reverse osmosis
 - Evaporation
 - Brine concentration/crystallization
 - Freeze/thaw
 - Natural treatment systems
 - Evaporation ponds
 - Brine disposal
 - Deep well injection
 - Industrial waste disposal facility
 - Beneficial use
 - Storage and use for winter road de-icing
 - Other beneficial uses for concentrated salt solution

As required by the WPDES permit, several chloride pollution prevention and source reduction measures are currently being implemented by the District, including:

- ※ Source reduction for industrial/commercial customers
- ※ Education of residential customers regarding use of residential zeolite softeners
- ※ Encouraging water softening efficiency improvements
- ※ Minimized use of chloride-containing chemicals at the NSWTP

The TBL screening process was used to identify three chloride compliance alternatives for further development and evaluation. These alternatives were selected during a workshop with the District's technical team, and include:

- ※ Source water softening at either individual water supply wells or a centralized treatment facility
- ※ Treatment of a portion of the NSWTP effluent using reverse osmosis and various degrees of brine minimization technologies
- ※ Treatment of a portion of the NSWTP effluent using electrodialysis reversal and various degrees of brine minimization technologies

Conceptual design information was developed for each of the three chloride compliance alternatives and variations. Based on an analysis of historical data, it was determined that a firm design capacity of 15 MGD would be required for the chloride treatment system at the NSWTP, in order to reliably achieve the target weekly average chloride limit of 395 mg/L during the future design year 2030. The system would need to operate at an average annual rate of 2.6 MGD during the current chloride and hydraulic loading conditions and at an average annual rate of 7.3 MGD during the future design year 2030. Chloride treatment rates are anticipated to vary seasonally, with higher treatment rates required during colder temperature months when chloride contributions to the NSWTP are the highest. For the source water softening alternatives, it was determined that the wells that supply approximately 60% of the NSWTP flow would need to be softened to offset an adequate amount of zeolite softener use during months with the highest chloride loads to the NSWTP, for a total softened water capacity of approximately 50 MGD.

Conceptual design information included a basis of design for source water softening and for chloride treatment at the NSWTP, identification and sizing of major treatment equipment, process flow diagrams and associated mass balances, and site plans. The primary focus of this study was to evaluate chloride compliance alternatives at the NSWTP, and therefore the alternatives related to treatment at NSWTP (Alternatives 2A, 2B, 2C, 3A, 3B, and 3C) were developed in somewhat greater detail than those that involved softening of the potable water supply (Alternatives 1A and 1B). Descriptions of the chloride compliance alternatives and conceptual designs are provided in Section 6.0. Details of the conceptual design information are provided in the appendices to this document. A summary of the chloride compliance alternatives is provided below.

Summary of Chloride Compliance Alternatives

Alternative		Description
1A	Source water softening – wellhead treatment for hardness (22 wells)	Treatment for removal of hardness at water supply source (and associated elimination of residential, commercial, and industrial zeolite water softeners). Treatment consists of membrane softening located at individual wells. It was assumed that 22 individual treatment systems each capable of softening a 3.0 MGD raw water supply would be required.
1B	Source water softening – centralized treatment for hardness (50 MGD firm capacity)	Treatment for removal of hardness from water supply at a centralized location (and associated elimination of residential, commercial, and industrial zeolite water softeners). Treatment consists of membrane softening located at a single centralized treatment site. It was assumed that the centralized system would be capable of producing 50 MGD of softened water. Infrastructure improvements to direct water from supply wells to the treatment facility and from the treatment facility to the distribution system are assumed to include 135 miles of watermain at a cost of \$1,000,000 per mile.

Alternative		Description
2A	Treatment at NSWTP using RO	Treatment of up to 15 MGD of NSWTP effluent using reverse osmosis technology for chloride removal. Treatment includes handling and disposal of up to 1.5 MGD of concentrated brine waste. Annual average treatment rate assumed to be 7.3 MGD for the future year 2030 design condition.
2B	Treatment at NSWTP using RO with brine minimization using evaporation	Treatment of up to 15 MGD of NSWTP effluent using reverse osmosis technology for chloride removal, followed by evaporation of brine to reduce volume for disposal. Treatment includes handling and disposal of up to 0.15 MGD of concentrated brine waste. Annual average treatment rate assumed to be 7.3 MGD for the future year 2030 design condition.
2C	Treatment at NSWTP using RO with brine minimization using evaporation and crystallization	Treatment of up to 15 MGD of NSWTP effluent using reverse osmosis technology for chloride removal, followed by evaporation and crystallization of brine to reduce volume for disposal. Treatment includes handling and disposal of up to 102 tons per day of concentrated brine waste. Annual average treatment rate assumed to be 7.3 MGD for the future year 2030 design condition.
3A	Treatment at NSWTP using EDR	Treatment of up to 15 MGD of NSWTP effluent using electrodialysis reversal technology for chloride removal. Treatment includes handling and disposal of up to 1.5 MGD of concentrated brine waste. Annual average treatment rate assumed to be 7.3 MGD for the future year 2030 design condition.
3B	Treatment at NSWTP using EDR with brine minimization using evaporation	Treatment of up to 15 MGD of NSWTP effluent using electrodialysis reversal technology for chloride removal, followed by evaporation of brine to reduce volume for disposal. Treatment includes handling and disposal of up to 0.15 MGD of concentrated brine waste. Annual average treatment rate assumed to be 7.3 MGD for the future year 2030 design condition.
3C	Treatment at NSWTP using EDR with brine minimization using evaporation and crystallization	Treatment of up to 15 MGD of NSWTP effluent using electrodialysis reversal technology for chloride removal, followed by evaporation and crystallization of brine to reduce volume for disposal. Treatment includes handling and disposal of up to 102 tons per day of concentrated brine waste. Annual average treatment rate assumed to be 7.3 MGD for the future year 2030 design condition.

Some key considerations for each alternative include:

1A – Source water softening – wellhead treatment for hardness removal

Treatment of a portion of the water supply to remove hardness using nanofiltration or reverse osmosis technology would eliminate the need for residential, commercial and industrial use of zeolite softeners, which contribute chloride to the sewer system. An estimated 22 individual treatment systems would be required for wellhead softening. This approach would minimize the need for modifications to the water distribution system, but would require construction and operation of a significant number of water treatment systems. Only those customers located in areas served by water treatment systems would receive softened water; therefore, not all customers served by the District would receive the same level of water service. This alternative would be successful only if customers served by softened water eliminated the use of their zeolite softening systems, which may be difficult to enforce by the District and its customer communities. Wastewater generated from the water treatment systems would be discharged to the District sewer system, and would result in increased hydraulic load to the NSWTP.

1B – Source water softening – centralized treatment for hardness removal (50 MGD firm capacity)

This alternative is similar to 1A, except that a single water treatment plant would be constructed and operated to soften a firm design capacity of approximately 50 MGD of water. The annual average operating capacity of the centralized water softening facility would be 23.8 MGD. Significant water distribution system improvements would be required to convey well water to the new water softening plant, and to transfer softened water back to the various existing water distribution pressure zones. Only a portion of the District's customers would receive softened water, and those customers would need to eliminate their use of zeolite softeners in order to achieve the required reduction in chloride load to the NSWTP. The hydraulic load to the NSWTP would increase due to discharge of wastewater from the centralized water softening plant.

2A – Treatment at NSWTP using reverse osmosis

Removal of chloride from a portion of the NSWTP effluent utilizing reverse osmosis technology would result in a blended effluent chloride concentration below the weekly average limit. Pretreatment would be required to remove low concentrations of suspended solids from the NSWTP secondary effluent and protect the reverse osmosis membranes from excessive fouling. The treatment system would be housed within a building, and would occupy a significant area at the NSWTP. A large volume of wastewater containing concentrated chloride would be generated by the reverse osmosis system, and would pose a significant challenge for storage, handling and disposal. It is expected that the wastewater, or brine, would need to be disposed off-site at a deep well disposal facility (outside of Wisconsin), or an industrial wastewater facility. The expected cost for disposal of the brine is substantial.

2B – Treatment at NSWTP using reverse osmosis and brine minimization using evaporation

This alternative is the same as 2A, with the addition of an evaporator system to reduce the volume of the brine produced by the reverse osmosis system. The evaporator system would require additional space at NSWTP, and would be housed within a building. The evaporator system requires substantial energy to evaporate water from the brine to reduce the volume for disposal. The capital and operating costs of the evaporator are significant; however, substantial savings in disposal cost are expected due to reduced brine volumes.

2C – Treatment at NSWTP using reverse osmosis and brine minimization using evaporation and crystallization

This alternative is the same as 2B, with the addition of a crystallizer system to further reduce the volume of the brine from the reverse osmosis system. The resulting waste product would be in the form of a slurry. The addition of the crystallizer system increases the space requirement, capital and operating costs compared to alternatives 2A and 2B. However, the hauling and disposal costs would be the lowest of the alternatives utilizing reverse osmosis treatment at the NSWTP.

3A – Treatment at NSWTP using electrodialysis reversal

Alternative 3A is similar to 2A, except that electrodialysis reversal technology would be used for removal of chloride from a portion of the NSWTP effluent instead of reverse osmosis. Electrodialysis reversal is less susceptible to fouling by suspended solids compared to reverse osmosis, and therefore pretreatment is not expected to be required. Electrodialysis reversal technology is currently available from only a single equipment supplier. The equipment would be housed within a building, and would require a significant amount of space at the NSWTP. Similar to reverse osmosis, a major drawback of this alternative is that a large volume of wastewater containing concentrated chloride would be produced, requiring storage and off-site disposal. Handling and disposal would represent a significant annual cost.

3B – Treatment at NSWTP using electrodialysis reversal and brine minimization using evaporation

This alternative is the same as 3A, with the addition of an evaporator system to reduce the volume of the brine produced by the electrodialysis reversal system. The evaporator system would require additional space at NSWTP, and would be housed within a building. The evaporator system requires substantial energy to evaporate water from the brine to reduce the volume for disposal. The capital and operating costs of the evaporator are significant; however, substantial savings in disposal cost are expected due to reduced brine volumes.

3C – Treatment at NSWTP using electrodialysis reversal and brine minimization using evaporation and crystallization

This alternative is the same as 3B, with the addition of a crystallizer system to further reduce the volume of the brine from the electrodialysis reversal system. The addition of the crystallizer system increases the space requirement, capital and operating costs compared to alternatives 3A and 3B. However, the hauling and disposal costs would be the lowest of the alternatives utilizing electrodialysis reversal treatment at the NSWTP.

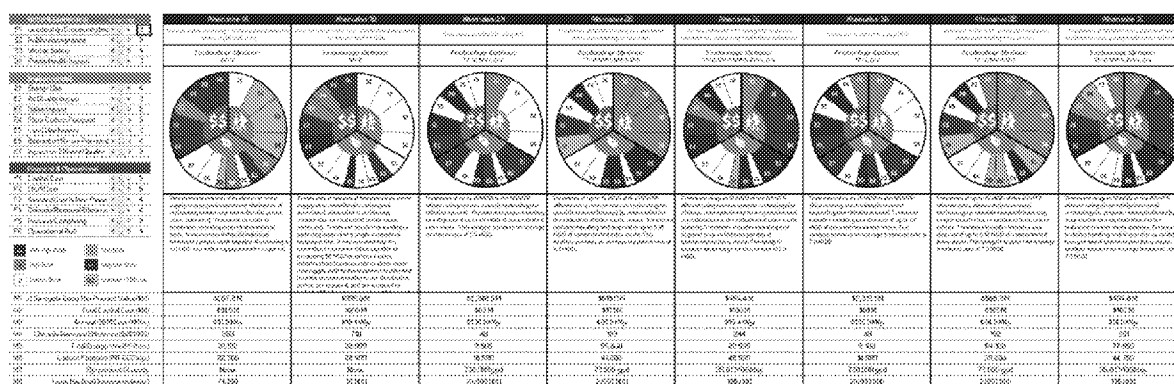
Projected capital, and annual operating and maintenance costs were developed at a conceptual level for the treatment alternatives summarized above. The estimated capital costs are consistent with a Class 4 estimate as defined by the Association for the Advancement of Cost Engineering International, with an expected accuracy range of -30% to +50%. The capital and annual costs were used to develop a net present value cost for each alternative. The projected capital, annual operating and maintenance, and net present value costs are presented in the following table. Annual operation and maintenance costs for the current operating condition (2.6 MGD annual average flow) and for the peak operating condition (15 MGD) are included in Section 7.0.

Conceptual Chloride Compliance Cost Projections

Chloride Compliance Alternative		Capital Cost	Annual O&M Cost Future Condition 7.3 MGD Average Flow	Net Present Value
Source Water Softening				
1A	Wellhead softening (22 well sites)	\$91,512,000	\$10,854,000	\$287,800,000
1B	Centralized softening (50 MGD firm capacity)	\$75,300,000	\$10,094,000	\$386,000,000
	Allowance for distribution system upgrades (135 miles at \$1,000,000 per mile)	\$135,000,000		
	Subtotal, centralized softening	\$210,300,000		
UF/RO Treatment at NSWTP				
2A	UF/RO with recovery RO	\$86,833,000	\$136,678,000	\$2,348,800,000
2B	UF/RO with recovery RO and evaporator	\$170,731,000	\$26,272,000	\$619,000,000
2C	UF/RO with recovery RO, evaporator and crystallizer	\$193,483,000	\$15,492,000	\$464,400,000
EDR Treatment at NSWTP				
3A	EDR	\$80,824,000	\$135,331,000	\$2,319,100,000
3B	EDR with evaporator	\$164,722,000	\$24,835,000	\$589,300,000
3C	EDR with evaporator and crystallizer	\$187,474,000	\$14,054,000	\$434,800,000

The District requested that a rough projection be made of the costs for treatment of all of the effluent from the NSWTP. Removal of chloride from all of the NSWTP effluent would result in an effluent that would contain a very low concentration of dissolved solids, which could be detrimental for discharge to the receiving streams. The cost and challenges associated with management and disposal of the waste stream produced by the chloride treatment system would also be significantly increased, and the treatment system would need to include equipment for reducing the volume of waste brine prior to off-site disposal or beneficial use. Capital and annual operation and maintenance costs for treatment of all of the NSWTP effluent were estimated by factoring the conceptual costs for the 15 MGD chloride treatment systems. The capital cost for a chloride treatment system sized for a capacity of 50 MGD is projected to range from \$500,000,000 to \$600,000,000; the annual operation and maintenance cost is projected to range from \$75,000,000 to \$150,000,000, depending on the extent of brine minimization and assuming off-site disposal of brine.

Data sheets were prepared for each alternative to provide input for the TBL analysis. Information was included for each of the 17 criteria selected by the District. The data sheets and the results of the TBL analysis are provided in **Appendix E**. A summary of the TBL analysis is shown below. An enlarged version of the TBL analysis is provided at the end of this Executive Summary.

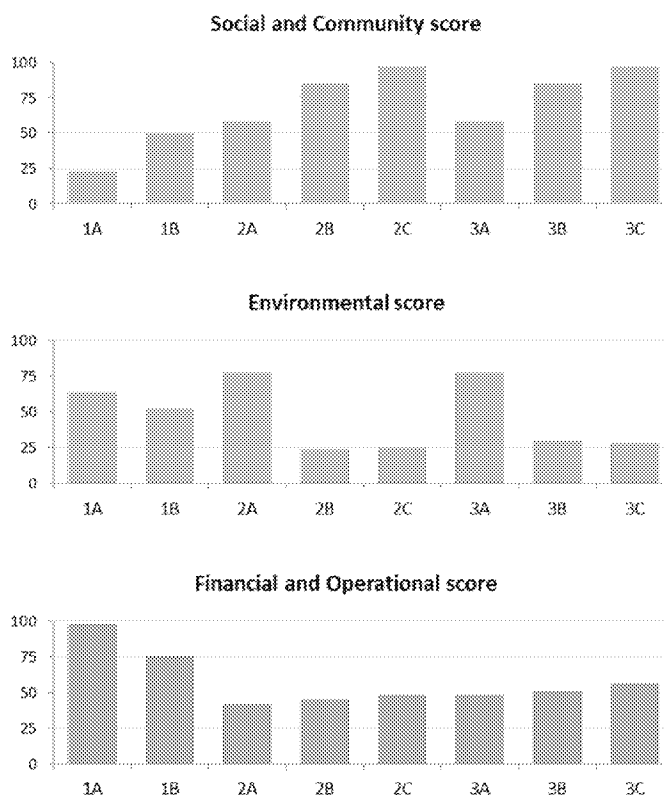


Each of the 17 criteria is color-coded by degree of positive and negative impacts on the criteria. The thickness of each slice is represented by the relative weights assigned by the District, thereby visually limiting or expanding the area of the circle represented by each criterion. A list of key performance metrics is included below each chart to provide quantified indicators such as total net present value cost, total energy use and carbon footprint.

The TBL analysis indicates that Alternatives 1A, 1B, 2A, 3A, and 3C rank the highest among the alternatives, with 1A achieving the highest overall score. However, each of these alternatives scores differently across the financial and operational, environmental, and social and community categories, making a single recommendation base on the analysis not immediately obvious.

A comparison of overall scores in the social, environmental, and financial categories is displayed in the adjacent graphs.

Alternative 1A had the strongest performance in the financial category, but scored the lowest of the alternatives in the social category. Alternatives 2A and 3A had strong overall performance in the environmental category, but have far higher costs and poorer performance in the financial and operational category. Within the social category, 2A and 3A have positive impacts with leadership/innovation and worker safety, but significantly negative impacts on public health. Alternatives 2C and 3C had the highest overall scores in the social category. When interpreting the results of the TBL analysis, note that the analysis is sensitive to the type of scoring and weighting factors selected by the AECOM and District review team. Some inputs to the TBL analysis rely on judgment as exercised by the evaluators.



The chloride compliance study provides information that can be used by the District, including chloride compliance alternatives and associated costs, to help determine an appropriate strategy for future compliance with the expected chloride discharge requirements at the NSWTP. The TBL analysis highlights the positive and negative impacts of the project alternatives with respect to financial, environmental and social externalities. Ultimately, the District and public representatives will need to weigh the negative consequences against the positive attributes of each alternative to select an optimum strategy for the greater Madison community. The strategy may require the cooperation of the District's customers, as well as other municipal agencies, to achieve the overall chloride compliance objectives in a manner that best meets the needs of the community.

Table 3-1

**Madison Metropolitan Sewerage District
Chloride Treatment Feasibility Study**

Comparison of Chloride Reduction Options – Source Reduction (SR)

Option	Location	Treatment Requirements	Chloride Reduction	Phosphorus & Nitrogen Removal	Residuals (Volume as percent of forward flow)	Capital Cost	Operation & Maintenance Costs	Benefits	Disadvantages
SR1 – Develop new water supply sources with lower chloride concentrations	Individual wells	Concentrations of Fe/Mn in deeper aquifers with lower chloride concentrations may require treatment via oxidation and filtration to meet secondary drinking water standards.	Minimal (less than 10% of chloride load is from source water)	None	None	Moderate (if Fe/Mn treatment is required)	Moderate (if Fe/Mn treatment is required)	<ul style="list-style-type: none"> Replacing high chloride water sources (50 to 120 mg/L chloride) may reduce overall chloride load to NSWTP approximately 5%. Could reduce costs for chloride treatment at NSWTP. 	<ul style="list-style-type: none"> Source water treatment may be required for Fe/Mn removal. Additional treatment for chloride would be required at NSWTP.
SR2 – Treatment for chloride removal at water supply source	Individual wells	Pretreatment: <ul style="list-style-type: none"> Cartridge filters, granular media filter, and/or microfiltration or ultrafiltration Treatment: <ul style="list-style-type: none"> Reverse osmosis, electrodialysis reversal, or anion exchange 	Up to 99% reduction in source water chloride, but minimal reduction of chloride at NSWTP (less than 10% of chloride load is from source water)	None	2-50%	High	High	<ul style="list-style-type: none"> In combination with other chloride source reduction measures, may be adequate to eliminate need for treatment at NSWTP. Some chloride removal technologies (reverse osmosis and electrodialysis reversal) provide removal of hardness, which may eliminate need for residential zeolite softening systems and resulting discharges of chloride to NSWTP. 	<ul style="list-style-type: none"> Treatment of water which may not require chloride removal (i.e. irrigation water) Relatively high cost for removal of approximately 8% of the chloride load to the NSWTP Multiple treatment facilities to be operated and maintained Brine disposal
SR3 –Treatment for removal of hardness at water supply source (and associated elimination of residential zeolite water softeners)	Individual wells	Pretreatment: <ul style="list-style-type: none"> Fe/Mn removal may be required prior to ion exchange or membrane-based softening technologies. Treatment: <ul style="list-style-type: none"> Lime softening, ion exchange (mineral acid regenerant), or nanofiltration 	Eliminating need for residential zeolite water softeners could result in 50 to 80% reduction in chloride load to the NSWTP.	None	5-50%	High	High	<ul style="list-style-type: none"> Improved potable water quality (reduced hardness, Fe and Mn) Reduces or eliminates need for residential water softeners and resulting chloride contributions Eliminates need for chloride treatment at NSWTP if residential water softeners are eliminated. 	<ul style="list-style-type: none"> Difficult to implement for individual wells. Potential exposure to hazardous chemicals depending on treatment technology Treatment of water which may not require softening (i.e. irrigation water) May require isolation of individual water distribution zones if not all wells are softened; could create dissatisfaction among customers Multiple treatment facilities to be operated and maintained Residuals disposal

Table 3-1

**Madison Metropolitan Sewerage District
Chloride Treatment Feasibility Study**

Comparison of Chloride Reduction Options – Source Reduction (SR)

Option	Location	Treatment Requirements	Chloride Reduction	Phosphorus & Nitrogen Removal	Residuals (Volume as percent of forward flow)	Capital Cost	Operation & Maintenance Costs	Benefits	Disadvantages
SR4 – Treatment for removal of chloride at centralized location(s)	One or more treatment facilities located within the water supply system	Pretreatment: <ul style="list-style-type: none"> Cartridge filters, granular media filter, and/or microfiltration or ultrafiltration Treatment: <ul style="list-style-type: none"> Reverse osmosis, electrodialysis reversal, or anion exchange 	Up to 99% reduction in source water chloride, but minimal reduction of chloride at NSWTP (less than 10% of chloride load is from source water)	None	2-50%	High	High	<ul style="list-style-type: none"> In combination with other chloride source reduction measures, may be adequate to eliminate need for treatment at NSWTP. Some chloride removal technologies (reverse osmosis and electrodialysis reversal) provide removal of hardness, which may eliminate need for residential zeolite softening systems and resulting discharges of chloride to NSWTP. 	<ul style="list-style-type: none"> Treatment of water which may not require chloride removal (i.e. irrigation water) Relatively high cost for removal of approximately 8% of the chloride load to the NSWTP. Brine disposal Central treatment requires substantial modifications to the distribution system and may not provide the same reliability as distributed water supply sources.
SR5 – Treatment for removal of hardness at centralized location(s)	One or more treatment facilities located within the water supply system	Pretreatment: <ul style="list-style-type: none"> Fe/Mn removal may be required prior to ion exchange or membrane-based softening technologies. Treatment: <ul style="list-style-type: none"> Lime softening, ion exchange (mineral acid regenerant), or nanofiltration 	Eliminating need for residential zeolite water softeners could result in 50 to 80% reduction in chloride load to the NSWTP.	None	5-50%	High	High	<ul style="list-style-type: none"> Improved potable water quality (reduced hardness, Fe and Mn) Reduces or eliminates need for residential water softeners and resulting chloride contributions Eliminates need for chloride treatment at NSWTP if residential water softeners are eliminated. 	<ul style="list-style-type: none"> Potential exposure to hazardous chemicals depending on treatment technology Treatment of water which may not require softening (i.e. irrigation water) Residuals disposal Requires significant new infrastructure to convey well water to centralized treatment facility prior to distribution Central treatment requires substantial modifications to the distribution system and may not provide the same reliability as distributed water supply sources.
SR6 - Industrial/commercial source reduction	Industrial and commercial sites	Treatment or elimination of chloride at individual industrial/commercial sites	Minimum impact at NSWTP	None	N/A	N/A	N/A	<ul style="list-style-type: none"> Reduces contributions of chloride from industrial/commercial users 	<ul style="list-style-type: none"> Potential for increased IPP and administrative requirements to monitor chloride reduction measures Increased cost to industrial / commercial customers

Table 3-1

Madison Metropolitan Sewerage District
Chloride Treatment Feasibility Study

Comparison of Chloride Reduction Options – Source Reduction (SR)

Option	Location	Treatment Requirements	Chloride Reduction	Phosphorus & Nitrogen Removal	Residuals (Volume as percent of forward flow)	Capital Cost	Operation & Maintenance Costs	Benefits	Disadvantages
SR7 - Educate residential customers and/or control/prohibit use of residential water softeners	Individual residential customers	N/A	Eliminating use of residential zeolite water softeners could result in 50 to 80% reduction in chloride load to the NSWTP.	None	N/A	N/A	N/A	<ul style="list-style-type: none">Reduces or eliminates largest source of chloride from the system	<ul style="list-style-type: none">Residential customers impacted by challenges associated with use of hard water
SR8 – Convert to use of higher efficiency water softeners	Individual residential customers	Replace residential zeolite softeners	Data to be provided by the District	None	N/A	N/A	N/A	<ul style="list-style-type: none">Reduces chloride load to NSWTP from residential water softeners	<ul style="list-style-type: none">Increased cost to residential customers

Table 3-2

**Madison Metropolitan Sewerage District
Chloride Treatment Feasibility Study**

Comparison of Chloride Reduction Options – Treatment at NSWTP (TP)

Option	Location	Treatment Requirements	Chloride Reduction	Phosphorus & Nitrogen Removal	Residuals (Volume as percent of forward flow)	Capital Cost	Operation & Maintenance Costs	Benefits	Disadvantages
TP1 – Reduce or eliminate use of chemicals at NSWTP which contribute chloride	NSWTP	N/A	Minimal	None	N/A	N/A	N/A	<ul style="list-style-type: none"> Minimal reduction (2%) of chloride load to NSWTP 	<ul style="list-style-type: none"> Reduced or alternate chemical use may negatively impact the NSWTP performance
TP2 – Treat a portion of NSWTP effluent using reverse osmosis technology	NSWTP	Pretreatment: <ul style="list-style-type: none"> Microfiltration or ultrafiltration, granular adsorption, and/or advanced oxidation Chloride Treatment: <ul style="list-style-type: none"> Reverse osmosis 	95 to 99% in treated effluent; desired removal achieved by blending treated and untreated effluent	Removal of dissolved and particulate phosphorus and nitrogen (ammonia, nitrate, nitrite)	15-50%	High	High	<ul style="list-style-type: none"> Provides barrier to microorganisms and anthropogenic organic contaminants Numerous operating systems in similar applications 	<ul style="list-style-type: none"> Susceptible to membrane fouling without sufficient pretreatment Requires high pressure to achieve high salt rejection (chloride removal) Significant use and disposal of cleaning chemical solutions Membranes are susceptible to damage by chlorine High volume of brine produced
TP3 – Treat a portion of NSWTP effluent using electrodialysis reversal technology	NSWTP	Pretreatment: <ul style="list-style-type: none"> Cartridge filters, granular media filter, microfiltration or ultrafiltration, granular adsorption, and/or advanced oxidation Chloride Treatment: <ul style="list-style-type: none"> Electrodialysis reversal 	50% to 95% (dependent on number of stages) in treated effluent; desired removal achieved by blending treated and untreated effluent	Removes dissolved ions which pass through the membrane; particulate phosphorus and nitrogen may be removed by EDR pretreatment system.	10%	High	High	<ul style="list-style-type: none"> Reduced pretreatment requirements compared to reverse osmosis Operates at lower pressure than reverse osmosis Less maintenance and longer membrane life than reverse osmosis Lower requirements for cleaning chemicals and associated disposal Compatible with chlorine concentrations <0.5 mg/L 	<ul style="list-style-type: none"> Larger foot print compared to reverse osmosis One U.S. manufacturer Less proven; only one full-scale wastewater treatment plant Susceptible to membrane fouling without sufficient pretreatment Significant power requirements Significant volume of brine produced
TP4 – Treat a portion of NSWTP effluent using anion exchange	NSWTP	Pretreatment: <ul style="list-style-type: none"> Granular media filter, microfiltration or ultrafiltration, granular adsorption, and/or advanced oxidation Chloride Treatment: <ul style="list-style-type: none"> Anion exchange (hydroxide based) 	95 to 99% in treated effluent; desired removal achieved by blending treated and untreated effluent	Potential to remove phosphate, nitrite and nitrate ions through ion exchange process; nitrate and nitrite are preferentially removed over chloride. Particulate phosphorus and nitrogen may be removed by pretreatment system	2%	Moderate	Moderate	<ul style="list-style-type: none"> Reduced pretreatment requirements compared to other technologies Potential for lower volume of brine waste compared to other technologies Lower power requirements compared to other technologies 	<ul style="list-style-type: none"> Prone to inorganic and biological fouling which may result in irreversible degradation of resins Sensitive to influent water quality fluctuations Large quantities of sodium hydroxide and sulfuric acid used for regeneration and pH balancing Limited application for treatment of municipal wastewater Other anions may be preferentially removed reducing the system capacity for chloride reduction Brine / chemical regenerant disposal

Table 3-3

**Madison Metropolitan Sewerage District
Chloride Treatment Feasibility Study**

Comparison of Chloride Reduction Options – Brine Minimization (BM)

Option	Location	Treatment Requirements	Chloride Reduction	Phosphorus & Nitrogen Removal	Residuals (Volume as percent of forward flow)	Capital Cost	Operation & Maintenance Costs	Benefits	Disadvantages
BM1 – Microfiltration / reverse osmosis	NSWTP	Concentration of primary chloride removal technology brine (reverse osmosis or electrodialysis reversal) using microfiltration and reverse osmosis	N/A	N/A	40-60%	Moderate	Moderate	<ul style="list-style-type: none"> Reduces brine volume Potential for beneficial reuse 	<ul style="list-style-type: none"> Significant use of chemical cleaning solutions which require disposal Membranes are susceptible to damage by chlorine Liquid waste produced Potentially hazardous chemicals present at low or non-detectable concentrations in the NSWTP effluent may be concentrated into the brine or solid material
BM2 – Lime softening followed by microfiltration / reverse osmosis	NSWTP	Lime softening for removal of divalent cations to improve the concentration factor that can be achieved by reverse osmosis; improving overall recovery rate; microfiltration used to protect reverse osmosis membranes	N/A	N/A	10-40%	High	High	<ul style="list-style-type: none"> Improves performance and recovery rate of the reverse osmosis process, resulting in a lower volume of concentrated brine Potential for beneficial reuse 	<ul style="list-style-type: none"> Solids produced by lime softening process require disposal Significant use of chemical cleaning solutions which require disposal Membranes are susceptible to damage by chlorine Liquid waste produced Potentially hazardous chemicals present at low or non-detectable concentrations in the NSWTP effluent may be concentrated into the brine or solid material
BM3 - Evaporator	NSWTP	Use of heat to evaporate water from brine, concentrating salts and reducing volume	N/A	N/A	2-10%	Very High	Very High	<ul style="list-style-type: none"> Produces less brine waste than reverse osmosis brine minimization alternatives 	<ul style="list-style-type: none"> Energy intensive Corrosion potential due to high chloride concentrations Potentially hazardous chemicals present at low or non-detectable concentrations in the NSWTP effluent may be concentrated into the brine or solid material
BM4 - Brine concentrator/crystallizer	NSWTP	Use of heat to evaporate water from brine, followed by further removal of water in a crystallizer	N/A	N/A	Produces solid material	Highest	Highest	<ul style="list-style-type: none"> Produces solid waste or product Potential for beneficial reuse 	<ul style="list-style-type: none"> Significant equipment and space requirements Complex operation Energy intensive Corrosion potential due to high chloride concentrations

Table 3-3

**Madison Metropolitan Sewerage District
Chloride Treatment Feasibility Study**

Comparison of Chloride Reduction Options – Brine Minimization (BM)

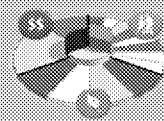
Option	Location	Treatment Requirements	Chloride Reduction	Phosphorus & Nitrogen Removal	Residuals (Volume as percent of forward flow)	Capital Cost	Operation & Maintenance Costs	Benefits	Disadvantages
									<ul style="list-style-type: none"> Potentially hazardous chemicals present at low or non-detectable concentrations in the NSWTP effluent may be concentrated into the brine or solid material
BM5 - Freeze/thaw	NSWTP / off-site	Freezing to produce ice crystals and further concentrate brine solution	N/A	N/A	25- 50%	Moderate	Low	<ul style="list-style-type: none"> Natural system No moving parts Simple operation 	<ul style="list-style-type: none"> Requires large land areas which would likely require lining Unproven technology Seasonal operational issues (storage required during above-freezing temperatures) Weather-dependent Liquid waste produced Potentially hazardous chemicals present at low or non-detectable concentrations in the NSWTP effluent may be concentrated into the brine or solid material
BM6 - Natural treatment systems (wetlands)	NSWTP / off-site	Plant and soil-based treatment for limited removal of chloride from brine	N/A	N/A	Liquid and sediment residuals; no loss other than evaporation	Moderate	Low	<ul style="list-style-type: none"> Limited mechanical equipment to operate and maintain Minimizes operational cost with the exception of periodic disposal and reconstruction 	<ul style="list-style-type: none"> Requires large land areas Likely requires a lined system Unproven technology Limited chloride removal Seasonal Very limited application for brine minimization Accumulation of chlorides requires periodic removal and landfill disposal of organic materials and sub soil followed by wetland reconstruction
BM7 - Evaporation ponds	NSWTP / off-site	Evaporation of water from brine in a pond	N/A	N/A	N/A	High	Low	<ul style="list-style-type: none"> Minimum operational cost 	<ul style="list-style-type: none"> Requires large surface areas Best suited for arid climates Requirement for liner system Ultimate disposal of residual solids in landfill.

Table 3-4

**Madison Metropolitan Sewerage District
Chloride Treatment Feasibility Study**

Comparison of Chloride Reduction Options – Brine/Residuals Disposal or Reuse (D)

Option	Location	Treatment Requirements	Chloride Reduction	Phosphorus & Nitrogen Removal	Residuals (Volume as percent of forward flow)	Capital Cost	Operation & Maintenance Costs	Benefits	Disadvantages
D1 - Beneficial reuse of reduced-volume brine or solids	Off-site	Brine or solids contain chloride and other salts which may have value for reuse	N/A	N/A	N/A	Moderate	Low	<ul style="list-style-type: none"> Beneficial reuse 	<ul style="list-style-type: none"> Must identify and maintain markets for beneficial reuse Storage may be needed if reuse is seasonal Potential presence of hazardous chemicals in the brine or solid material
D2 - Storage for winter use in road de-icing	NSWTP / off-site	Storage of brine or solids for use in seasonal road de-icing	N/A	N/A	N/A	High	Low	<ul style="list-style-type: none"> Beneficial reuse Reduces cost for de-icing chemicals 	<ul style="list-style-type: none"> Significant storage capacity may be required Chloride may be re-introduced into influent to NSWTP if used for de-icing Potential presence of hazardous chemicals in the brine or solid material
D3 – Deep well injection	NSWTP / off-site	Disposal of brine via deep well injection	N/A	N/A	N/A	Low (for existing deep wells)	High	<ul style="list-style-type: none"> Eliminates chloride from watershed 	<ul style="list-style-type: none"> Not permitted per Wisconsin code Haul to another state for disposal Off-site hauling poses risk and significant cost Corrosion potential of well materials due to high chloride content
D4 - Off-site disposal of reduced-volume brine or solids	Off-site	Disposal of brine or solids at industrial waste facility or landfill	N/A	N/A	N/A	Low	High	<ul style="list-style-type: none"> Eliminates chloride from watershed 	<ul style="list-style-type: none"> Waste characterization would be required to determine ultimate landfill or disposal facility requirements Off-site hauling poses risk and significant cost



MMSD Chloride Treatment Technology Options
Triple Bottom Line Assessment

☒ Assign Criteria Weighting Manually (From 0 to 5) ☐ Remove N/A [Show / Hide Scores](#)

Social & Community		Weighting
S1	Leadership/Community Image	3
S2	Public Acceptance	3
S3	Worker Safety	4
S4	Public Health Impact	3

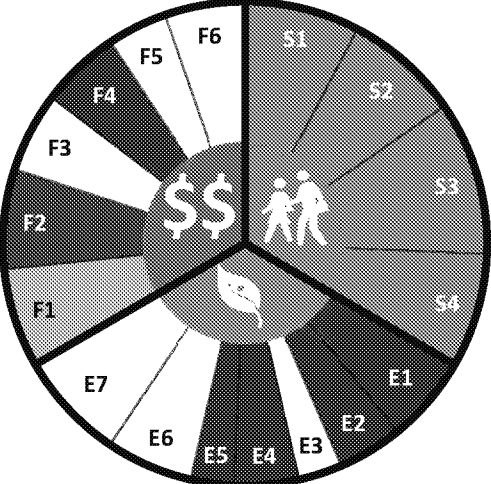
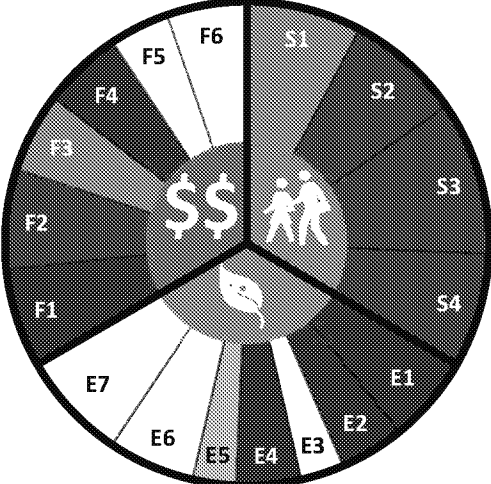
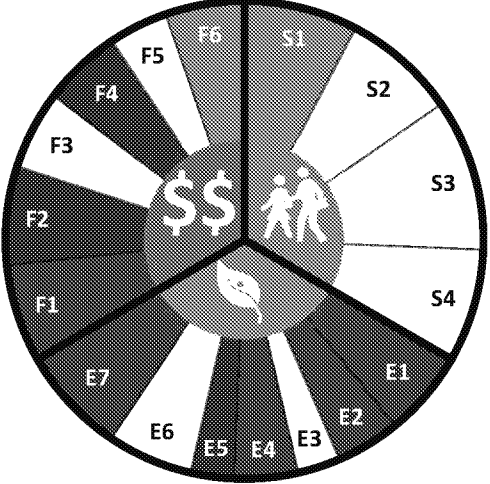
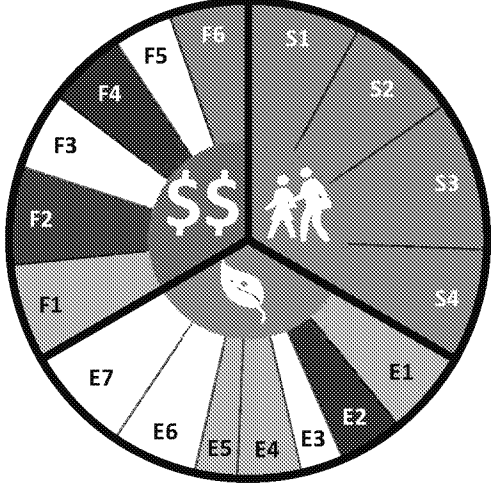
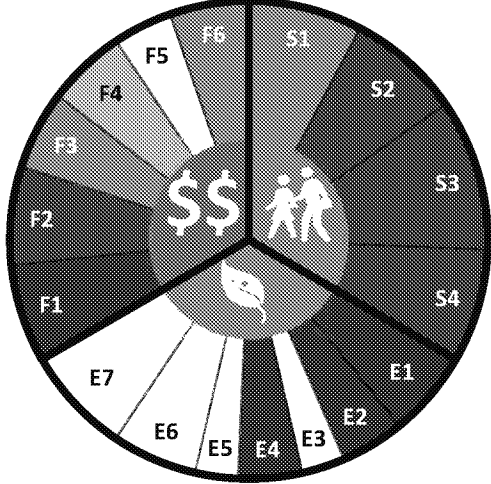
Environmental		Weighting
E1	Energy Use	4
E2	Air Quality Impact	3
E3	Noise Impact	2
E4	Plant Carbon Footprint	3
E5	Land Use Impact	2
E6	Byproduct Reuse Potential	4
E7	Impact on Effluent Quality	3

Financial & Operational		Weighting
F1	Capital Cost	5
F2	O&M Cost	5
F3	Avoided Cost & New Revenue	4
F4	Chloride Removal Efficiency	4
F5	Process Complexity	3
F6	Operational Risk	4

++	Very High Score	-	Low Score
+	High Score	--	Very Low Score
O	Medium Score	TBD	Unknown / TBD / NA

M1	Total Life-cycle Costs Net Present Value(\$M) :	
M2	Total Capital Cost (\$M) :	
M3	Annual O&M Cost (\$M/yr) :	
M4	Chloride Removal Efficiency (lb/\$1000) :	
M5	Total Energy Use (MWh/yr) :	
M6	Carbon Footprint (MT CO2e/yr) :	
M7	By-product Quantity :	
M8	Truck Hauling Distance (miles/yr) :	

Alternative 1A	Alternative 1B	Alternative 2A
Source water softening - Wellhead treatment for hardness (50 well sites)	Source water softening - Centralized treatment for hardness (50 MGD)	Treatment at NSWTP using RO
<i>Technology Options:</i> SR-3	<i>Technology Options:</i> SR-5	<i>Technology Options:</i> TP-2, BM-1, D-3
Treatment for removal of hardness at water supply source (and associated elimination of residential, commercial and industrial zeolite water softeners). Treatment consists of membrane softening located at individual wells. It was assumed that 22 individual treatment systems each capable of softening a 3.0 MGD raw water supply would be required.	Treatment for removal of hardness from water supply at a centralized location (and associated elimination of residential, commercial, and industrial zeolite water softeners). Treatment consists of membrane softening located at a single centralized treatment site. It was assumed that the centralized system would be capable of producing 50 MGD of softened water. Infrastructure improvements to direct water from supply wells to the treatment facility and from the treatment facility to the distribution system are required, and are assumed to include 135 miles of watermain at \$1M per mile.	Treatment of up to 15 MGD of the NSWTP effluent using reverse osmosis technology for chloride removal. Treatment includes handling and disposal of up to 1.5 MGD of concentrated brine waste. This analysis assumes an average treatment rate of 7.3 MGD.
\$287.8 M	\$386.0 M	\$2,348.8 M
\$91.5 M	\$210 M	\$87 M
\$10.9 M/yr	\$10.1 M/yr	\$136.8 M/yr
953	710	48
31,100	39,000	8,500
22,700	28,400	16,500
None	None	730,000 gpd
71,250	30,000	21,900,000

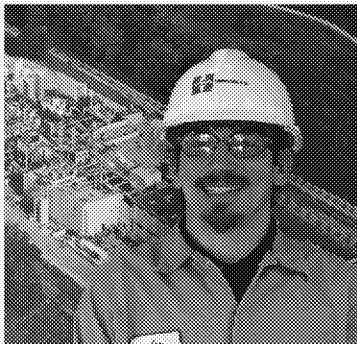
Alternative 2B	Alternative 2C	Alternative 3A	Alternative 3B	Alternative 3C
Treatment at NSWTP using RO and brine minimization using evaporation	Treatment at NSWTP using RO and brine minimization using evaporation/crystallization	Treatment at NSWTP using EDR	Treatment at NSWTP using EDR and brine minimization using evaporation	Treatment at NSWTP using EDR and brine minimization using evaporation/crystallization
<i>Technology Options:</i> TP-2, BM-1, BM-3, D-3	<i>Technology Options:</i> TP-2, BM-1, BM-3, BM-4, D-4	<i>Technology Options:</i> TP-3, D-3	<i>Technology Options:</i> TP-3, BM-3, D-3	<i>Technology Options:</i> TP-3, BM-3, BM-4, D-4
				
Treatment of up to 15 MGD of the NSWTP effluent using reverse osmosis technology for chloride removal followed by evaporation for the reduction of brine waste volume. Treatment includes handling and disposal of up to 0.15 MGD of concentrated brine waste. This analysis assumes an average treatment rate of 7.3 MGD.	Treatment of up to 15 MGD of the NSWTP effluent using reverse osmosis technology for chloride removal followed by evaporation and crystallization for the reduction of brine waste quantity. Treatment includes handling and disposal of up to 102 tons per day of concentrated brine waste. This analysis assumes an average treatment rate of 7.3 MGD.	Treatment of up to 15 MGD of the NSWTP effluent using electrodialysis reversal technology for chloride removal. Treatment includes handling and disposal of up to 1.5 MGD of concentrated brine waste. This analysis assumes an average treatment rate of 7.3 MGD.	Treatment of up to 15 MGD of the NSWTP effluent using electrodialysis reversal technology for chloride removal followed by evaporation for the reduction of brine waste volume. Treatment includes handling and disposal of up to 0.15 MGD of concentrated brine waste. This analysis assumes an average treatment rate of 7.3 MGD.	Treatment of up to 15 MGD of the NSWTP effluent using electrodialysis reversal technology for chloride removal followed by evaporation and crystallization for the reduction of brine waste quantity. Treatment includes handling and disposal of up to 102 tons per day of concentrated brine waste. This analysis assumes an average treatment rate of 7.3 MGD.
\$619.0 M	\$464.4 M	\$2,319.1 M	\$589.3 M	\$434.8 M
\$171 M	\$193 M	\$81 M	\$165 M	\$187 M
\$26.3 M/yr	\$15.4 M/yr	\$135.3 M/yr	\$24.8 M/yr	\$14.0 M/yr
183	244	49	192	261
66,600	80,000	6,100	64,100	77,600
41,000	46,500	14,800	39,200	44,700
73,000 gpd	36.8 CYDS/day	730,000 gpd	73,000 gpd	36.8 CYDS/day
2,550,000	135,000	21,900,000	2,550,000	135,000

Attachment F – Small Business Case Study

Save money, cut salt at the source

Reducing salt use minimizes pollution and cuts business costs.
Madison Metropolitan Sewerage District has grants and technical expertise to help.

Learn more and apply for funds at: www.madsewer.org/smartsaltuse. Most wastewater treatment plants are not designed to remove salt. Each day 100 tons of salt from water softeners and other sources pass through the district's plant and enter area surface waters. It's far cheaper to reduce salt at the source than build and power costly new treatment infrastructure. The district funds projects to reduce water softener and road salt, which keeps sewer bills low for everyone. The following examples highlight business leadership in these efforts.



Ian Henderson, engineer,
Hydrite Chemical

Hydrite Chemical

•Salt savings: 3,843 pounds per month from two brine reclamation projects (3,250 pounds per month) and replacement of a water-cooled boiler pump with an air cooled system (593 pounds per month).

Hydrite Chemical Co. produces and distributes chemicals for agriculture, industry, food production and more. The company's continuous improvement team focuses on projects that increase process efficiency and cut costs.

A team member learned about technology to recycle still-usable brine in water softeners at a district salt reduction workshop. With funding from district rebates, Hydrite implemented brine reclamation systems on two softeners at the Cottage Grove facility and saved about 39,000 pounds of salt per year. The company was so pleased it implemented brine reclamation in Oshkosh; Terre Haute, Ind.; Waterloo, Iowa; and Lubbock, Texas, with payback periods of less than three years without rebates.

Hydrite also reduced its use of softened water. In Cottage Grove, a system that used soft water to cool a boiler pump was replaced with a system that uses air to cool the pump. The move cut Hydrite's soft water use by about 900,000 gallons per year, which also reduced the company's water bill.

Clean Water Act permit limits require a 30,000 pound per day reduction in salt use by area homes and businesses over the next five years. Rather than build expensive new infrastructure, the most cost effective solution for ratepayers is to reduce local salt use at the source.



Joe Baldwin, general manager,
Best Western PLUS InnTowner

Best Western PLUS InnTowner

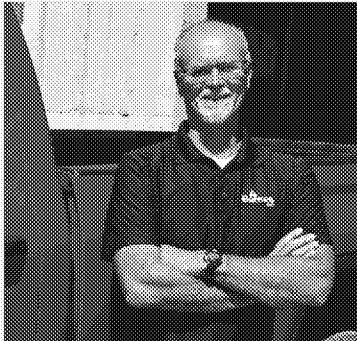
•Salt savings: At least 557 pounds per month by replacing old, malfunctioning water softeners with new high-efficiency softeners with brine reclamation.

After a multi-million dollar renovation of its rooms, the Best Western PLUS InnTowner hotel in Madison upgraded its mechanical systems. The resin in the old water softener had deteriorated with age and the unit was inefficient and leaking.

Spurred by a rebate from the district, the hotel installed new, efficient softeners with brine reclamation. The \$1,000 rebate covered about 10 percent of the total cost. Since installation, the hotel's issues with hard water have ceased and hotel staff and management have noted the reduction in salt.

“Most of the brine reclaim jobs I’ve done have a payback of around three years. This payback time can be reduced by using the district’s grant funds.”

– **Regi Licht**, Commercial Sales Engineer,
Total Water Treatment Systems



Steve Kamps, plowing and landscaping, Barnes Inc.

Barnes Inc.

•Salt savings: 3.2 tons per snow event in winter 2017-18 after incorporating brushes and brooms into snow removal and teaching applicators about using the right amount of salt.

Barnes Inc., a landscaping and snow removal company, provides winter maintenance services to more than 150 commercial buildings and 300 residential customers throughout Dane County. Barnes took action to reduce salt use through changes in equipment and company practices.

Several employees were trained and certified through the City of Madison’s winter salt certification program, which recognizes salt applicators that have taken a course on proper salt application rates. Barnes also applied for a road salt reduction grant from the district to purchase brushes and brooms for snow removal trucks that increase the effectiveness of removing snow and ice without salt.

Barnes also has worked to instill a company culture of proper salt application. Managers educated employees about proper salt use and discouraged over-application of salt. When quality control staff spot-checked sidewalk routes, they began evaluating sites for proper salt use as well as snow removal. Through these practices, Barnes has significantly reduced salt use during winter weather events.

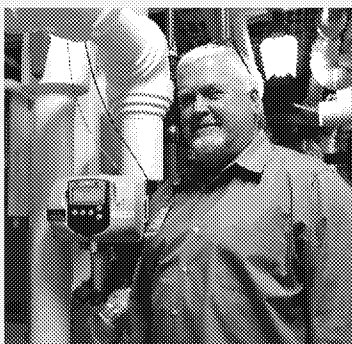
UnityPoint Health – Meriter

•Salt savings: 4,261 pounds per month through new conditioning processes.

UnityPoint Health-Meriter Hospital in Madison has implemented several projects to reduce salt use including different methods to condition water for heating and cooling systems.

First, Meriter installed several “Green Machines” that use electricity rather than salt to condition makeup water for cooling towers. Since installing the devices, the hospital has prevented 140 tons of softener salt from entering the sewer.

Meriter also has replaced water softening with other processes for a salt savings of 51,135 pounds per year. The hospital achieved this salt reduction total – 4,261 pounds per month – by switching from a water softener to chemical treatment prior to the reverse osmosis system.



Ryan Unzicker, facilities manager,
UnityPoint Health Meriter

To learn more about how your business can save money by reducing salt use, contact Emily Jones, pollution prevention specialist, EmilyJ@madsewer.org, (608) 222-1201.